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CAMBRIAN FORAMINIFERA: CHAPMAN'S SPECIES FROM THE DOLGELLY BEDS OF ENGLAND

By B. F. Howell and J. R. Sandidge

Paleontologists throughout the world are busily engaged in pushing back the dark curtains which hide the pictures of the early stages of the evolution of living things on the earth. Each year they bring to view new scenes in the pageant of the life of the ancient seas of early Paleozoic times. Sometimes, when one of these new pictures is first seen, its meaning is not entirely comprehended. Its full evolutionary significance is understood only later, when other related pictures have been uncovered and studied. New evidence helps us to interpret old facts and to piece together the long Chain of Life.

Some thirty years ago an English paleontologist, Mr. F. M. Chapman, now of the Australian National Museum, described some tiny fossils, that he recognized as foraminifera (the group of one celled animals which build for themselves shells of various substances), which had been found by Professor Theodore Groom, of Oxford University, in beds of late Dolgelly this is, of late Cambrian age near the village of Whiteleaved Oak, in the Malvern Hills, of England. Mr. Chapman described and named these fossils,[1] and deposited them in the paleontological museum of Oxford University.

At the time when Mr. Chapman's description appeared, only a few paleontologists were particularly interested in foraminifera. Since then, however, the great petroleum industry has found these and other tiny fossils extremely useful in the search for oil, and as a result a great impetus has been given to the study of foraminifera, as well as of all other small fossils. This has led to a rapid development of the branch of the science of paleontology popularly called micropaleontology, which is concerned mainly with the foraminifera. The growth of interest in this group of animals has led to an increased interest in the evolution and classification of the order. Much information on the history of the group since early Carboniferous times has been gathered and published, but only a little has been learned about the Cambrian, Ordovician, Silurian, and Devonian ancestors of the Carboniferous and later forms. Mr. Chapman's Cambrian species have increased in significance and in importance to paleontologists with the growth in our knowledge of, and interest in, foraminifera in general. It has become evident that they should be reexamined in the light of modern knowledge of the order.

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[1] Chapman, F. Foraminifera from an Upper Cambrian horizon in the Malverns; together with a note on some of the earliest known Foraminifera. Quarterly Journal of the Geological Society of London, v. 56, 1900, p. 257–263, pl. XV. Chapman F. The Foraminifera, London, 1902, p. 253, 254, text fig. 27.

Through the kindness of Professor W. J. Sollas, of Oxford University, the senior author has been able to study such of these specimens as are known to be preserved at Oxford, and to secure the new photograph of them which is here presented. The fossils are preserved in a thin section of limestone on a single microscope slide. They were presumably found in a thin lens, or concretion, of limestone, as they came from the Dolgelly Beds, which contain no thick limestones. As can be seen from Chapman's illustrations, here reproduced, they are well preserved. They are the only well-preserved foraminifera of undoubted Cambrian age that have yet been described in print. It is believed that such a summary of what is known about them as is here presented will be of sufficient interest and value to paleontologists to make its publication desirable.

A comparison of these late Cambrian fossils with recently described Ordovician and Silurian species seems to indicate that the Cambrian species are probably primitive types, generally corresponding in their shape and form to the Ordovician and Silurian representatives of the order, but having shells of different composition. Since it recently has been shown by Dr. Moreman[2] that in Ordovician and Silurian times foraminifera with arenaceous tests were present in the seas of the world, it seems highly probable that the Cambrian foraminifera had shells of chitinous material. This suggestion is supported by the delicacy of the tests in the species figured by Chapman. That they were arenaceous is highly improbable, while the likelihood of their having been siliceous is precluded by the fact that the fossils are calcareous. The calcium carbonate may be a mineral replacement of the chitinous shell, such as occurs in the fossilization of many trilobite remains. That the earliest foraminifera had chitinous tests is generally recognized; and the prevalence of chitinous tests among Cambrian representatives of the order, postulated on the evidence furnished by Chapman and Moreman, is, therefore, here suggested as a possibility.

The exact nature of Cambrian foraminifera cannot be determined until more of them have been studied than have thus far been available. Students of the Cambrian are therefore urged to seek for additional material, so that more light may be thrown on the important problem of the early evolution of this interesting group of animals.

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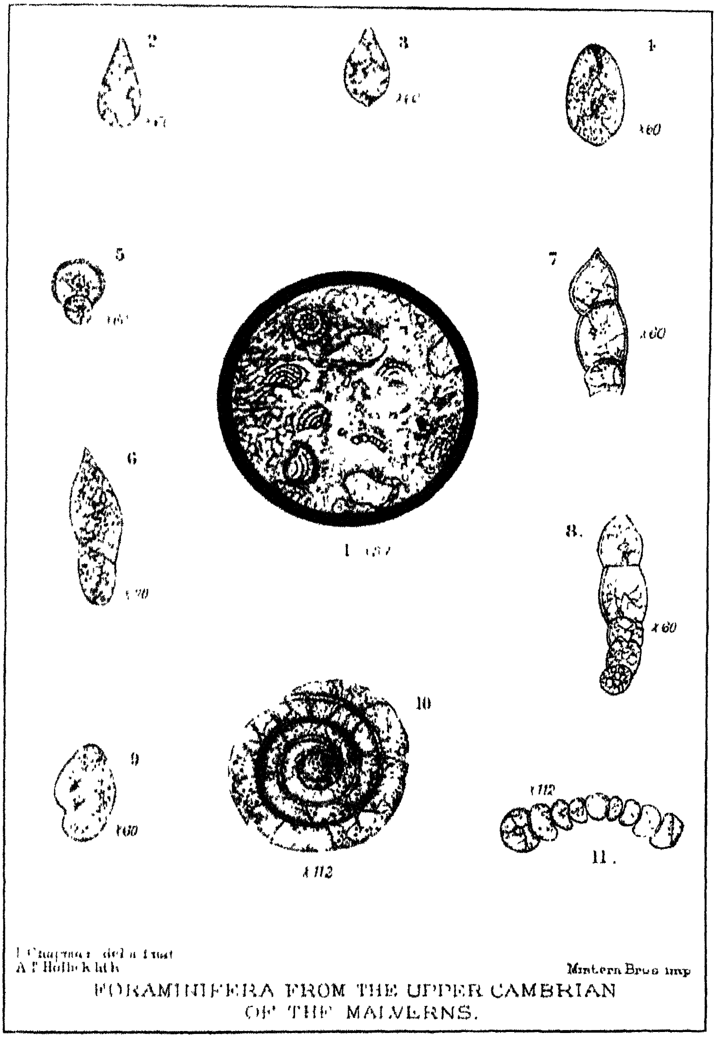
[2] Moreman, W. L.: Arenaceous Foraminifera from Ordovician and Silurian Limestones of Oklahoma, Jour. Pal., vol. 4, 1930, pp. 42 59.

PLATE I



Copy of the plate from Chapman's original description of the Cambrian foraminifera from the Malvern Hills of England. Published in the Quart. Jour. Geol. Soc. of London, Vol. 46, 1900.

EXPLANATION OF PLATE I

1. Shaly limestone with *Spirillina groomii* Chapman in section. × 37.
2. *Lagena laevis* (Montague). × 60.
3. *Lagena apiculata* (Reuss). × 60.
4. *Lagena ovum* (Ehrenberg). × 60.
5. ? *Nodosaria (Glandulina)* sp., cf. *Glandulina pygmaea* Terquem. × 60.
6. *Nodosaria (Dentalina) abnormis?* (Reuss). × 70.

7, 8. *Marginulina soluta* (?) Reuss. × 60.

9. *Cristellaria acutoauricularis?* (Fichtel and Moll). × 60.
10. *Spirillina groomii* Chapman. Lateral aspect. × 112.
11. The same. Peripheral aspect. × 112.

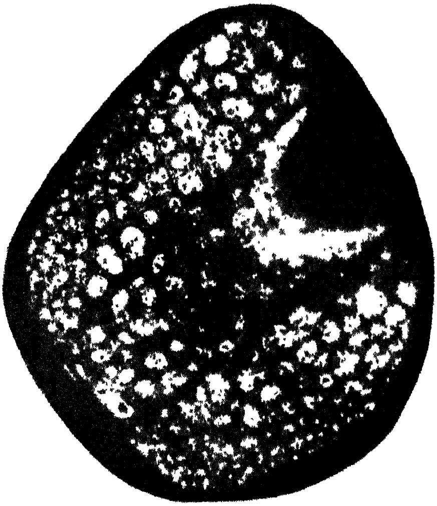


Fig. 1.—Photograph of the slide containing the thin section of Cambrian rock from the Malverns. × 10 (approximately). Photo. by Sollas.

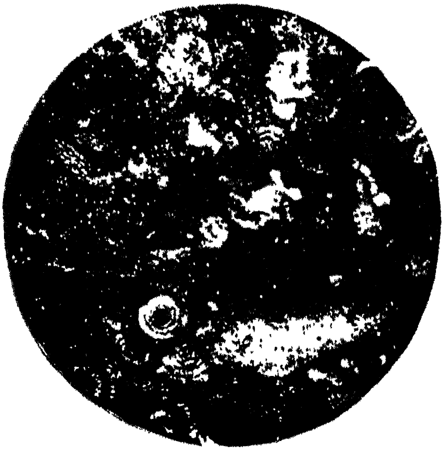


Fig. 2.—Chapman's "Spirillina Rock; Upper Cambrian, Malverns. × 30." Reproduced from "The Foraminifera," by courtesy of the publishers, Longmans, Green and Co.

This is an enlarged view of a portion of the slide shown in Fig. 1.

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A RÉSUMÉ OF THREE LECTURES ON

SOCIAL RELATIONS IN MONKEY, APE AND MAN

By Robert M. Yerkes

Professor of Psychobiology and Director of Laboratories of Comparative Psychobiology, Yale University

Lectures delivered under the Richard B. Westbrook Free Lectureship Foundation at the Wagner Free Institute of Science
January 26, 27 and 28, 1933

LECTURE I: PRIMATE TYPES AND SOCIAL PROGRESS

Man is preëminently a social animal; so are the great apes. Some insects, notably types of ant and bee, also are social, but insect society is colonial, while that of apes is individualistic. Ants exhibit marked differentiation of structure and function, but in apes the chief differences are those of sex. In the ant colony the individual is subordinated to the group, while in the ape, individuality constantly expresses itself. Ants may be said to look backward in social evolution; apes, on the contrary, look forward.

Which, we may ask, should have precedence: the individual or the group? The question may be answered intelligently only in the light of careful comparative study of social evolution and development. Wheeler, an eminent authority on the subject, states that the ant society is primarily one of females, which live in a condition of anarchistic socialism without dominant leadership. It appears, by contrast, that the sexes and individuals among apes are associated for species preservation and individual development, under a leadership which is autocratic.

Animal associations have been classified by Espinas as accidental (parasitism, commensalism, mutualism) and as normal (nutritional, reproductive, and economic). Among the primates, reproductive and economic types of association are conspicuously important and there are abundant evidences of mutuality of feeling, attachment, sympathy, and incipient altruism.

As a simple working classification of significant types of primate social behavior we propose the following three categories: (1) self-preservative and self-developing activities, such as food-getting, play, etc.; (2) reproductive activities, and as the mating pattern, the reproductive cycle and care of young; and (3) social service activities, and as the transition from care of young to mutual aid of members of the group and acts which appear to us altruistic.

The subsequent lectures are to be based on observations of four types of primate: the howlers, a relatively lowly type of New World monkey; the baboons, a type of Old World monkey; the anthropoid apes, including orang-outan, chimpanzee, and gorilla; and, finally, man.

Howlers are found in Central and South America. At this time Dr. C. Ray Carpenter is conducting a study of the social life of these animals on Barro Colorado Island, the Canal Zone. He finds that they are relatively slow, phlegmatic, peaceful, arboreal, polygamous, and individualistic. They do not build nests and make slight use of objects as tools. The population of the island is about four hundred. There are some twenty-three distinct clans, each with its own territory. The average number of individuals in the clan is sixteen, of which two are adult males, five to seven adult females, and five to seven immature individuals. The males give no attention to the young, and the females markedly less than is true of the anthropoid apes and of man.

The baboon, one of the largest of Old World monkeys, is doglike in appearance, relatively pugnacious, and terrestrial, preferring open rocky places. Dr. Zuckerman, who has studied baboons both in South Africa and in London, has most interestingly described their social characteristics in his book, "The Social Life of Monkeys and Apes." Mutuality of service, as in grooming, appears much more frequently in the baboon than in the howler.

Of the three existing types of great ape—orang-outan, chimpanzee, and gorilla—the first two are approximately the size of man, whereas the gorilla is much larger. In color of coat the orang-outan is light to dark brown or reddish; the chimpanzee, dark gray to black; and the gorilla, gray to black. The orang-outan is native only to Borneo and Sumatra, while both chimpanzee and gorilla are native only to Africa. Chimpanzees are more widely distributed than either orang-outan or gorilla, and much more abundant. Probably of all the great apes the gorilla is the most rare. In temperament the young orang-outan is shy and relatively pensive; the young chimpanzee, gay and sportive; the young gorilla, serious and self-centered.

(The several types of primate as described above were exhibited in lantern slides.)

LECTURE II: SOCIAL DEPENDENCE AND SOCIAL DOMINANCE

In summarizing the previous lecture the speaker indicated as contrasting types of social organization the subordination of the individual to the group, as in the colonial insects, and the development of the individual or self-realization through organization and coöperation, as in the primates. Instinct, as exhibited by the former, is characterized by uniformity of behavior-pattern, whereas intelligence, as evident in the latter, gains expression in initiative and diversity of action.

As biological experiments the types of great ape appear to be relatively unsuccessful. The chimpanzee and orang-outan may be holding their own in numbers, but without doubt the gorilla is diminishing.

Among the many socially significant differences between monkeys, apes, and men, the following may be mentioned. The time of gestation tends to increase from the relatively primitive to the advanced types of primate: in monkeys it is five to six months; in the great apes, probably seven to nine months; in man, approximately nine months. The young at birth are increasingly helpless and infancy is prolonged from monkey to man. The young monkey may move about freely within four weeks; the great ape requires three to four months, and man from twelve to sixteen months. While in some of the prosimians multiple births are common, in the monkeys and great apes, as in man, single births are the rule. Thus the importance of the individual is emphasized. A considerable degree of self-dependence is achieved by the young monkey within six months, by great apes in one to two years, and by man in four to six years. The monkey may be sexually mature in two or three years, the great ape in seven to ten years, and man in twelve to fifteen years. Likewise the variety and importance of parental care increases from monkey to man, and especially, in general, the rôle of the father as guide and entertainer. Parental tuition or education of the young progressively increases from monkey, through the great apes, until in man it reaches its highest known point of development.

It appears that punishment is more frequent than reward as a condition of tuition in the great apes, and that in general the infants learn more than do other types of mammal from the example of their parents and from social tradition. It is indicated, for example, that fear of snakes and other dangerous natural objects, instead of being definitely inherited as pattern of behavior, is acquired by observation of companions and by individual experience. Thus the mature chimpanzee may exhibit terror at sight of a snake, whereas the infant may pay little heed to it. Likewise fear of fire, which may be extreme in the adult ape, may be relatively slight in the infant.

Shyness, timidity, and fear are often mistaken in captive apes for contrariness, perversity, or unwillingness to coöperate with man. As a result the animals often are unfairly and unintelligibly treated. Conspicuous among the lessons taught by long association with the anthropoid apes as subjects of scientific experiment are the importance of patience, sympathetic understanding, and just treatment. The chimpanzee, deceived or abused by man, eventually will have its revenge.

In the great apes undoubtedly dependence throughout the prolonged period of infancy and childhood is highly favorable to the acquisition of profitable experience. Herein is discovered the chief biological advantage of the long period of relative helplessness. Imitativeness, which is conspicuous in the early stages of human development, and also in that of the great apes, tends gradually to diminish, and in late life it is slight. A fad or fashion may appear in the chimpanzee colony today and be taken up almost immediately by all young members of the group.

In every primate group, but conspicuously in many of the monkeys and in the great apes, there exists an order of social importance, influence, or dominance. Ordinarily there is a single leader. This position in the other primates is filled by natural process, while in man the process of selection is highly artificial and often ignores physical and mental fitness.

Progress, defined as profitable biological change, is observable in the primate order. Conspicuous exhibits are the increasing significance of social tradition and of the influence of the elders. Observation of the chimpanzee especially suggests such questions as: Can communistic types of organization succeed in individualistic primate societies? Can the reproductive functions profitably be specialized and entrusted to certain members of the social group? Can an industrial type of social organization permanently sustain itself? It is probable that we shall be considerably helped toward the solution of such questions by open-minded study of the development and evolution of social behavior, relations, and institutions in our fellow primates.

(This lecture was followed by a cinema record which told the story of chimpanzee development from infancy to maturity and exhibited various activities.)

LECTURE III: THE EVOLUTION OF SOCIAL SERVICE

Throughout these lectures organic evolution as a natural process has been assumed a fact. The evidences of such process are abundant and their significance too great to be ignored.

In this the concluding lecture of the series, social service, or the dawn of altruism, is the principal topic for consideration. One often meets the question: Does the world owe the individual a living, or indeed anything? A possible answer is: It depends on the individual! From various points of view it seems clear that self-sacrifice often is biologically justified.

Unquestionably altruistic behavior is more conspicuous in man than in any other known organism. It may be shadowed forth in some of the lowly types of monkey, but clearly it exists in impressive form in the great apes. Everywhere its manifestations vary with the individual and with circumstances of life. The trend toward increase of altruistic interest and activity would appear to be one of the most significant aspects of primate evolution.

"Grooming" is a socially significant behavior-pattern which exhibits mutuality of interest and service. One manifestation of this activity is commonly known as flea-picking. The essential features of grooming are visual examination, search and manipulation of the skin and hair of a companion with fingers and lips, removal of dirt, dandruff, scabs, parasites, and other extraneous materials, and their conveyance to the mouth of the groomer, whose lips, tongue, and jaws meanwhile may have been in motion, with sound production, as if in anticipation of something to be swallowed. Commonly swallowing ensues, if the object is not disagreeable. Such behavior is conspicuous in the chimpanzee.

Grooming may well be the center of origin of many highly developed forms of primate social service. Little is definitely known about its development in the individual or its racial history, but it is a reasonable hypothesis that it represents a genetically important pattern of primate social response, from which have evolved incomparably useful forms of social service, and that it represents a step in the socialization of primate behavior and stands as forerunner of human hair and skin-dressing, nursing, and medical and surgical treatment.

Something analogous to grooming appears in many of the carnivores and in almost all domesticated animals. In the Prosimiae, such as lemurs, it consists chiefly of licking and scratching or combing. In the howler monkeys there is much self-grooming, but rarely is the activity mutual. Baboons, however, are notable for their indulgence in mutual grooming. This is true also of the chimpanzee. In primitive human groups the activity corresponding to grooming is known as delousing.

Anthropologists have commonly assumed that human delousing is a cultural phenomenon, or, in other words, that it is transmitted by social tradition instead of being inherited by the individual. Whether this assumption is correct has not been established. Nor is it definitely known whether grooming, as observed in the monkeys and great apes, is inherited as behavior-pattern or acquired by individual experience and observation of companions.

Undoubtedly grooming is a significant variety of social service. It conduces to mutual understanding, sympathy, confidence, and friendliness among chimpanzees. It obviously is mutual, not determined by dominance.

What is wrong with the world is that many things are wrong with human nature. Selfishness, acquisitiveness, dishonesty, and anti-social attitude and conduct are omnipresent in our civilization, and as human traits and expressions they are manifestly responsible for most of our individual and social ills and misfortunes. To them we owe also some of our blessings, for nothing in life is absolutely bad. We are born more or less selfish and acquisitive, actually and potentially. Individual differences in these respects are so pronounced that everyone notices them. We spend our lives in an environment which more or less encourages and intensifies self-seeking.

Our individual traits, no less than our social relations and institutions, within limits are modifiable and controllable. It is a primary task and opportunity of human engineering to establish biological and social conditions which shall eliminate undesirable degrees of self-seeking and favor the growth of social-mindedness.

The question as to how human nature and the social order can be changed is not a new one, and although the answer at present must be tentative, its nature is clearly indicated. Establishments for biological research are steadily contributing facts, principles, and methods of control. Intelligent experiments in social organization and in forms of government are being made the world over. Progress is definitely observable. Man is in a bad plight individually and collectively, but he is not static.

Looking then to possibilities which may at any moment become lively actualities, human nature is modifiable by selective breeding, by physiological controls, and by modes of educational treatment. The social-economic order may be changed by wisely guided imaginative construction and clear-headed coöperative action. Limitations of our abilities in these directions may not profitably be ignored, but neither need they be accepted as insurmountable. Those who characterize as impossible the modification of human nature in essential respects and the achievement of a social order radically different from the one in which we live are obviously on weaker ground than persons who with knowledge, insight, faith, and determination predict and strive for human betterment.

We chance to live in a social-economic order, called capitalism, which places extraordinarily heavy premiums on acquisitiveness and the condition of mind favored thereby. Our society measures success in terms of wealth and power. Unquestionably the growth of social-mindedness and the encouragement of giving above getting, demand a social order in which personality is recognized as of supreme worth and material possessions ranked as of minor importance.

While students of mind and conduct are seeking basic knowledge and serviceable methods for the modification of human nature, statesmen and lay citizens alike can profitably join forces in intelligent and determined efforts so to transform or replace the present type of social organization and of government that the level of human life may be lifted to a plane worthy of our mentality and the values of life enhanced.

(The lecture was followed by a cinema record of chimpanzees and gorillas in various types of psychobiological experiment.)

The reader who wishes to learn more about anthropoid life will find abundant information in "The Great Apes," by Robert M. Yerkes and Ada W. Yerkes (Yale University Press, 1929).

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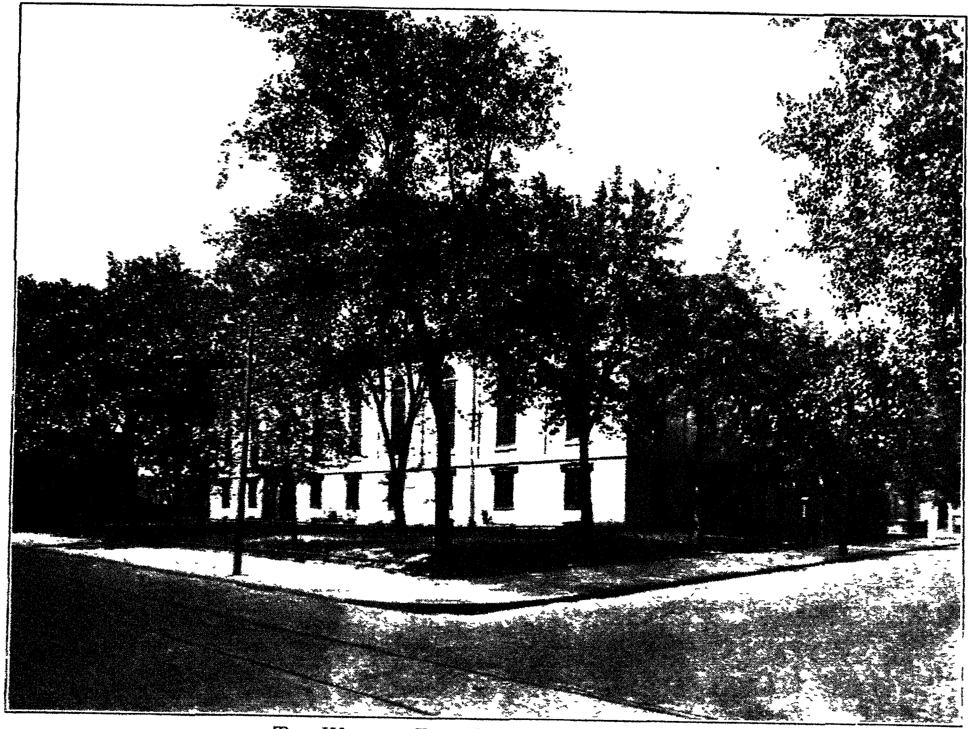

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SYDNEY L. WRIGHT, JR., *Editor*

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WAGNER FREE INSTITUTE OF SCIENCE

Montgomery Ave. and Seventeenth St., Philadelphia, Pa., U. S. A.

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William B. Scott, A.M., Ph.D., LL.D.	Geology
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ADMINISTRATIVE

Department of Engineering
John Wagner, Jr., B.S., C.E.

Department of Biology
Samuel C. Schmucker, Ph.D., Sc.D., *Zoology*
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Department of Physical Science
Leslie B. Seely, B.A., *Physics*
David W. Horn, Ph.D., *Inorganic and Physical Chemistry*
Ivor Griffith, Ph.M., *Organic Chemistry*

Department of Geology and Paleontology
Benjamin F. Howell, A.M., Ph.D.

Carl Boyer, *Director*

HISTORICAL NOTE

The Wagner Free Institute of Science owes its establishment to the liberality and public spirit of William Wagner and his wife, Louisa Binney Wagner. In his early life Professor Wagner made extensive voyages in the service of Stephen Girard, and had opportunities to visit scientific institutions and make the acquaintance of scientific workers. He soon developed a strong interest in the natural sciences, especially geology and mineralogy, and devoted a large part of his life to studying these topics and collecting material to illustrate the teaching of them.

In 1847 he began to give free lectures at his home, near the present location of the Institute building, at that time in the rural section of the county. In 1855 the Institute was incorporated by the Legislature, a faculty was appointed and lectures were given at Commissioners' Hall, Thirteenth and Spring Garden Streets, by permission of the city authorities. In a few years the city was obliged, by its own needs, to withdraw the privilege of the hall, and Professor Wagner arranged to erect a suitable building on his own property. This was completed in May, 1865, and lectures at once given in it. In 1864 a deed of trust was executed by Professor Wagner and his wife, furnishing a permanent endowment of the Institute.

In 1885, by the death of the founder, the care of the Institute passed into the hands of a Board of Trustees, since which time many improvements have been made in the building, and extensive additions to the equipment in the museum and library and in scientific apparatus. In 1901 a wing was built for the use of a branch of the Free Library of Philadelphia.

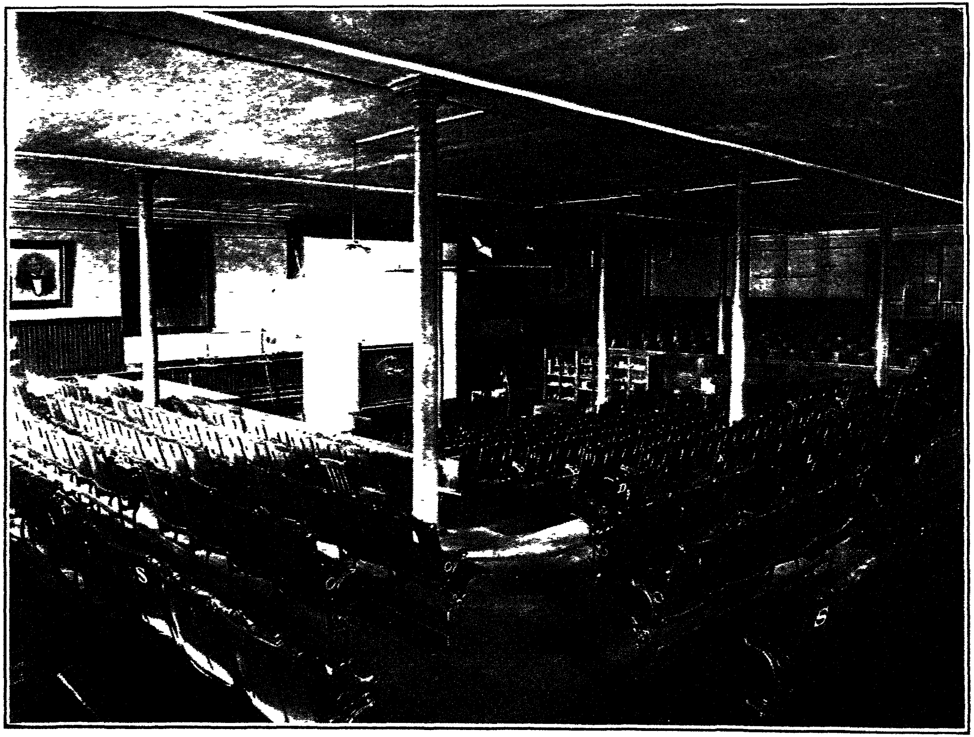
FACILITIES FOR INSTRUCTION

Lectures and Class-Work

Instruction at the Wagner Free Institute of Science is conducted by means of public lectures, supplemented by class-work, and is without charge and without restriction of race or sex. The class-instruction is given partly at the close of each lecture, partly by written exercises. The Museum and Reference Library of the Institute are available for aid in the instruction work and are freely used. In addition, the Wagner Institute Branch of the Free Library of Philadelphia affords abundant opportunities for collateral reading.

At the close of each course of lectures an examination is held, to which those who have attended the classes are admitted, and on passing such examination the pupil is awarded a certificate. Certificates are awarded at a public meeting held in May of each year.

The lecture courses are arranged to cover a given topic in four



AUDITORIUM

MUSEUM

successive years, and to those who hold certificates for each of these courses a full-term certificate is issued.

MUSEUM

The Museum covers the whole field of natural science and contains illustrations in all departments of biology, geology, mineralogy, metallurgy, and engineering. The specimens are arranged so as to be easily studied and are open to inspection from 2 to 5 o'clock Wednesday and Saturday afternoons, except legal holidays.

Teachers with classes and others desiring to use the museum for special studies can, by applying at the office, gain admission any week-day, except holidays, as above stated, between the hours of 9 A. M. and 5 P. M.

The collections of the museum have been used for a number of years for instruction by means of "Museum Talks," as noted below, and by arrangement with work at Temple University and the Division of Science Teaching of the Board of Public Education those teaching General Science in the eighth and ninth grades of the Philadelphia public schools or preparing for such teaching may secure elective credits upon the completion of the work as follows:

General Science II

Monday,	7 P. M. to 8 P. M.	Museum Lecture.
	8 P. M. to 9 P. M.	Lecture Course—Botany and Zoology.

NOTE: Four semester hours of credit will be given for the complete Monday evening program.

Tuesday,	8 P. M. to 9 P. M.	Lecture Course—Inorganic Chemistry and Geology.
Wednesday,	8 P. M. to 9 P. M.	Lecture Course—Organic Chemistry and Physics.

NOTE: An additional two semester hours of credit per evening may be obtained by electing Tuesday or Wednesday evening.

Monday evening is a prerequisite for these, however.

Further information concerning these courses may be obtained at the Office of the Institute.

LIBRARIES

The Reference Library contains text-books and works of reference in all departments of science, encyclopedias, many works devoted to literature, and an assortment of dictionaries of English, classical and foreign languages. It is open on all regular business days from 9 A. M. to 9 P. M., a librarian being in attendance to assist students.

The Circulating Library is a branch of the Free Library of Philadelphia. Books may be taken out under the usual rules of the Free Library. Many periodicals—American and foreign, scientific and literary—are on file.

BULLETIN

The BULLETIN of the Institute is quarterly. It contains information as to the methods of work of the Institute, announcements of additions to its collections and original contributions to science. The eighth volume is now in course of publication. The subscription price is $1.00 per year, single copies, 25 cents.

SPECIAL LECTURES

By the liberality of Richard Brodhead Westbrook, D.D., for many years a trustee of the Institute, and of his wife, Henrietta Payne Westbrook, provision has been made for lectures independent of the general courses of the Institute and covering a wide range of topics. A list of lectures so far given and of publications thereof so far as issued is printed on page 91.

Announcement of the course for 1934 will be made in a subsequent issue of the BULLETIN.

The income of a fund given by Dr. Henry Leffmann is applied to providing special lectures as the Fannie Frank Leffmann Memorial Lectureship.

The *Philadelphia Natural History Society* meets on the third Thursday of each month, except June, July and August. These meetings are open to all persons interested in the subjects.

RESEARCH

The Institute has carried on research work since 1885, most of the results having been published in its Transactions and Publications. A list of these will be found on page 92. Results of research appear also from time to time in the BULLETIN.

The Henry Leffmann Chemistry Research Fund has been established for perpetual service.

CLOSING EXERCISES

In May of each year the courses of instruction are formally closed by a public meeting at which addresses are given and the certificates awarded.

At the closing exercises in May, 1933, after an address by Professor S. C. Schmucker, Dean of the Faculty, and awarding of certificates, Captain Carl von Hoffman, Explorer, delivered a lecture entitled, "Head Takers of Formosa."

FULL TERM CERTIFICATES AWARDED

BOTANY

Emanuel Hocking
Herbert F. Schearer

ORGANIC CHEMISTRY

J. Oakley Hendry
Frank P. Ingenito

GEOLOGY

Clifton V. Mimms
Mrs. Reba A. G. Mimms

ZOOLOGY

Winifred L. Bardsley
Raymond D. Downey
Harry W. Fisher
May H. Hunter
Frank P. Ingenito

1932-1933 CERTIFICATES AWARDED

BOTANY 2

Myra H. Burford
Harry W. Fisher
George Gordon
Mrs. Marie E. Gordon
Rose E. Green
Emanuel Hocking
Florence A. Jones
Mrs. Reba A. G. Mimms
Kenneth J. Noecker
Jules A. Riehs
Benjamin N. Roberts
Fannie A. Root
Albert J. Rosenheimer
Herbert F. Schearer
Herbert F. Schearer, Jr.
Leonard Silverman
George M. Snyder

INORGANIC CHEMISTRY 4

George W. Baker
Charles Brooke
Hugo L. Bruegel
Burton J. Cherney
John Dick
William D. S. Gillette
John G. Glenn
Rose E. Green
Susie M. Hampton
Herman H. Hofeld
John J. Kane
H. J. Magnin
Reid W. Malcolm
Clifton V. Mimms
Mrs. Reba A. G. Mimms
William R. Patterson
William A. Pavlo
George Richards
Jules A. Riehs
Benjamin N. Roberts
Floyd E. Roberts
Albert Rosenheimer
Helena M. Torrisi
Mrs. Josephine M. Wild
William J. Young

ORGANIC CHEMISTRY 4

George W. Baker
Burton J. Cherney
Mrs. Ruth H. Duke
William D. S. Gillette
John F. Glenn
Stewart Gray
Rose E. Green
Susie M. Hampton
William Heck
J. Oakley Hendry
John C. R. Hofferbert
John G. Hope
Frank P. Ingenito
Florence V. Johnston
Edward W. Jones
John J. Kane
Mrs. Dorothy G. Lloyd
John T. McCabe
Harry J. Mackell
Howard J. Magnin
Reid W. Malcolm
Mrs. Reba A. G. Mimms
William R. Patterson
William A. Pavlo
Benjamin N. Roberts
Albert Rosenheimer
Carl J. Schwab
Nathan Silver
Helena M. Torrisi
Norman W. Trew
Frank Worthington

ENGINEERING 2

George W. Baker
Edgar A. Burt
Charles L. Danser
Henry V. Deppisch
Jack Dunn
Edward H. Gillette
Chester J. Hickok
John J. Kane
George Nichols
Arthur H. M. Smith

GEOLOGY 2

John H. Antrim
Harry W. Fisher
John F. Glenn
Rose E. Green
William Heck
Herman H. Hofeld
Ruth A. Jackson
John J. Kane
Robert P. Kemble
William J. Lindley
Clifton V. Mimms
Mrs. Reba A. G. Mimms
Harold B. Poole
John W. Quinn
Benjamin N. Roberts
Albert Rosenheimer
William E. Schlessman
Frederick F. Schmitt
Gerard F. Schmitt
Walter W. Stillwagon
Charlotte L. Temple
John H. Turri
Sylvia B. Young
William A. Young

ZOOLOGY 1

John H. Antrim
Winifred L. Bardsley
Raymond D. Downey
Francis F. Fink
Harry W. Fisher
Wilma E. Gaines
George Gordon
Mrs. Marie B. Gordon
Hyman L. Grabosky
Rose E. Green
John C. R. Hofferbert
Dorothy M. Hunsinger
May H. Hunter
Frank P. Ingenito
John J. Kane
May A. Leonard
Mrs. Reba A. G. Mimms
John W. Quinn
Jules A. Riehs
Benjamin N. Roberts
Albert Rosenheimer
Mrs. Maude H. Schearer
Edmund F. Schmitt
Frederick F. Schmitt
Leonard Silverman
George M. Snyder
Charlotte L. Temple
Dr. Henry Winsor
Sylvia B. Young

PHYSICS 3

Burton J. Cherney
John F. Glenn
Rose E. Green
Rowland W. Johnson
John J. Kane
William J. Lindley
William J. Nagel
John W. Quinn
Benjamin N. Roberts
Albert Rosenheimer
Thomas L. Scatchard
Charlotte L. Temple
Norman W. Trew
Mrs. Josephine M. Wild
Dr. Henry Winsor

FACULTY

SAMUEL CHRISTIAN SCHMUCKER

A.M., M.S., Sc.D., Muhlenberg College.
Ph.D., University of Pennsylvania.
For thirty years Professor of Biological Sciences, State Teachers College, West Chester, Pa.
For twenty years head of Science Department, Summer Schools, Chautauqua, N. Y.
For fifteen years Lecturer on Biology, Brooklyn Institute of Arts and Sciences.
Professor of Botany, Wagner Free Institute of Science, 1908–1926.
Professor of Zoology, Wagner Free Institute of Science, 1926 to date.
Dean of the Faculty.
Author of
"The Study of Nature." (Lippincott Co.)
"The Meaning of Evolution."
"Man's Life on Earth."
"Heredity and Parenthood." (Macmillan Co.)

JOHN WAGNER, JR.

B.S. in C.E. 1913, University of Pennsylvania.
C.E. 1920, University of Pennsylvania.
Assoc. M., Am. Soc. C. E.
1913–1916, Draftsman, Phoenix Bridge Company.
1916–1921, Office of Engineering Bridges and Buildings, Pennsylvania Railroad, including two years' service with the Army as First Lieut. and Captain in the Cavalry.
1921–1926, Assistant Supervisor Track, Reading Company.
1926–1928, Supervisor Track, Reading Company.
1928 to date, Industrial Agent, Reading Company.
Professor of Engineering, Wagner Free Institute of Science, 1926 to date

LESLIE BIRCHARD SEELY

Graduate, State Normal School, Bloomsburg, Pa.
Taught school, Luzerne and Snyder Counties, Pa.
Assistant instructor in physics and chemistry, Bloomsburg, 1899–1902.
Graduate, Haverford College, 1905.
Head Master, Friends Institute, Chappaqua, N. Y., 1905.
Instructor in physics, Northeast High School, Philadelphia, 1906–1915.
Head of Science Department, Germantown High School, 1915–1923.
Principal, Roxborough High School, 1923–1924.
Principal, Germantown High School, 1924 to date.
Graduate courses, University of Pennsylvania and Brooklyn Institute, 1906–1910.
Honorary degree of Doctor of Pedagogy, Ursinus College, 1926.
Professor of Physics, Wagner Free Institute of Science, 1912 to date.
Publications:
"Description of Two New Distomes," Biological Bulletin, Lancaster, Pa., 1906.
"Ether Waves and the Messages They Bring."
"The Physics of the Three-electrode Bulb," Transactions of the Wagner Free Institute of Science.

DAVID WILBUR HORN

A.B., Dickinson College, 1897.
A.M., Dickinson College, 1898.
Ph.D., Johns Hopkins University, 1900.
Assistant in Chemistry, Johns Hopkins University, 1900–1901.
Associate and Associate Professor of Chemistry, Bryn Mawr College, 1901–1907.
Lecturer in Hygiene, Hahnemann Medical College, 1911 to date.
Head of Pre-Medical School of Science, Hahnemann Medical College, 1916–1921.
Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science, 1921 to date.

Professor of Inorganic and Physical Chemistry, Wagner Free Institute of Science, 1911 to date.
Chairman of Philadelphia Section of American Chemical Society, 1904 and 1905.
Fellow of American Association for the Advancement of Science.
Fellow of the Royal Society of Arts of London.

IVOR GRIFFITH

Early education at the Bethesda Academy, Wales, and came to America in 1907.
P.D., Philadelphia College of Pharmacy and Science, 1912.
Ph.M., Philadelphia College of Pharmacy and Science, 1921.
Director of Research, John B. Stetson Company, 1925 to date.
Director of Laboratories, Stetson Hospital, 1916 to date.
Editor, American Journal of Pharmacy, 1921 to date.
Associate Professor of Pharmacy, Philadelphia College of Pharmacy and Science, 1914 to date.
Professor of Organic Chemistry, Wagner Free Institute of Science, 1926 to date.
Secretary of the Faculty of Wagner Free Institute of Science.
Fellow of the American Institute of Chemists.
Fellow of the American Association for the Advancement of Science.
Fellow of the Pennsylvania Academy of Science.
Publications:
  "Recent Remedies," 1926 (revised 1928).
  "Popular Science Lectures" (Editor) (eight volumes).
  U. S. Dispensatory (Collab. Editor).
  Formula Book, A. Ph. A. (Editor).
  Contributor to current chemical, pharmaceutical and medical literature.

GEORGE BRINGHURST KAISER

Educated in private schools.
Graduate, Franklin School.
After graduation spent several years in intensive botanical study and field work in northeastern United States.
Secretary of the Botanical Society of Pennsylvania for seven years and leader of its field trips.
Instructor in Botany, School of Horticulture for Women.
Professor of Botany, Wagner Free Institute of Science, 1927 to date.
Curator, Moss Herbarium, Sullivant Moss Society.
Treasurer, Delaware Valley Naturalists' Union.
Member, Academy of Natural Sciences.

BENJAMIN FRANKLIN HOWELL

B.S., A.M., Ph.D., Princeton University.
Associate Professor of Geology and Paleontology, Princeton University.
Professor of Geology and Paleontology, Wagner Free Institute of Science, 1927 to date.
Curator of Invertebrate Paleontology in Princeton University.
Fellow of the Paleontological Society.
Secretary of the Paleontological Society.
Fellow of the Geological Society of America.
Fellow of the American Association for the Advancement of Science.
Member of the Palaeontologische Gesellschaft.
Associate Member of the Society of Economic Paleontologists and Mineralogists.
Member of the Committee on Micropaleontology of the National Research Council.
Chairman of Cambrian Subcommittee of U. S. National Research Council Committee on Stratigraphy.
Editor of the section of General Paleozoology of *Biological Abstracts.*
American Editor of Palaeontologisches Centralblatt.
Specializes in Cambrian Paleontology and Geology.
Associated with U. S. Geological Survey, the U. S. National Museum, Geological Survey of Canada, Canadian National Museum, Geological Survey of Vermont, Geological Survey of Montana, as a consulting paleontologist and research associate.

REGULAR LECTURES, SESSION OF 1933–1934

BOTANY 3

PROFESSOR KAISER

Taxonomy

Lectures begin at 8 P. M.

1. Monday, September 11.
   Gramineae. Cyperaceae. Flowers of the grasses, wind-pollinated, lacking high color, scent or nectar, clothe the earth in feathery filigree. Some of their products are Bread, the Staff of Life, made from wheat, rye, barley, rice, corn, millet, sugar and the bamboo of many uses. The papyrus of antiquity was made from the pith of a sedge.

2. Monday, September 18.
   Palmae. Araceae. "Breadths of tropic shade, and palms in clusters, knots of paradise." Cocoanuts, dates, Panama hats, wine, arrack, sugar and betel nuts yielded by the palm. The Arums are closely related with strange flowers that lure insects with the odor of carrion. Here are found Jack-in-the-Pulpit, skunk cabbage, calla, calamus, golden club, and the dumb cane, which may deprive man of speech.

3. Monday, September 25.
   Liliaceae. Amaryllidaceae. Iridaceae. "Lilies of all kinds, the flower-de-luce being one," included in the order Liliiflorae. Gorgeous lilies of the field and garden, tulip and hyacinth, the stately amaryllis and her kin, iris, gladiolus and crocus, the latter yielding saffron, whose adulteration was once punished by death, are found here. Onions and asparagus are lilies, too!

4. Monday, October 2.
   Orchidaceae. The effete race of orchids results from over-specialization. In certain genera a flower may remain open awaiting the visit of a particular insect even unto the end of eighty days. The rarely beautiful aërial species of the tropics display endless variants of color and fragrance and the earth-orchids of our temperate climes offer a fascinating field for study. True vanilla is obtained from the capsule of an orchid.

5. Monday, October 9.
   Betulaceae. Fagaceae. The exquisite Lady of our North Woods is the white or paper canoe birch, and red, yellow and sweet birches are also wonderfully graceful trees with unisexual flowers in delicate catkins. Both sexes are borne on the same tree, as is also the case in the beech and the oak, the majestic monarch of our forests. The oaks of the earth are many. They are long-lived and afford enduring timber.

6. Monday, October 16.
   Ranunculaceae. Nymphaeaceae. Magnoliaceae. The first group of flowering plants to be arranged in a natural classification was the crowfoot family, Ranunculaceae. The garden of Louis XV was the scene of the preliminary studies of the botanist Antoine Laurent de Jussieu. In this family may be clearly studied the evolution of a nectary from buttercup to columbine and larkspur. The attractive water lilies and magnolias are close to the crowfoots in their primitive floral structure.

7. Monday, October 23.
   Papaveraceae. Cruciferae. The story of opium is wrapped up in the story of the sleep-bearing poppy. The oriental and other species deck our gardens with brilliant bloom. Our native bloodroot of the spring is a member of this group. Closely akin are the mustards with their many forms of cabbage, turnip, radish, and water cress, as well as our candytuft, wall flower, alyssum and stock. The caper and bleeding heart belong to closely allied families.

8. Monday, October 30.

Rosaceae. "Gather ye rose-buds while ye may,
Old Time is still a-flying,
And this same flower that smiles today
Tomorrow will be dying."

The queen of flowers was sacred to Venus. Her many stamens may readily be changed to petals thus enabling the horticulturist to create endless forms of double roses. The flowers are similar throughout the family but a most diverse fruit is seen in apple, pear, quince, peach, plum, cherry, blackberry, raspberry, strawberry and the less familiar medlar and loquat.

9. Monday, November 6.

Leguminosae. We find in this family peas, beans, groundnuts, and lentils, as well as the sensitive plant, acacia, logwood, Kentucky coffee tree, locust, licorice and a host of plants useful to man in the arts. Members of this order show an interesting development of a so-called "butterfly-flower" and the fruit, which is always a pod, called a legume, is well marked.

10. Monday, November 13.

Umbelliferae. Araliaceae. Cornaceae. Celery, carrots, parsnips, fennel and parsley, the funeral decoration of the Greeks; anise, asafoetida, coriander and caraway are found in the highly aromatic umbel-bearing family of uniform inflorescence, whose fruit is a cremocarp. Nearly related are the ginseng and the English ivy, our beautiful dogwood, other ornamental cornels and the sourgum, whose foliage flames scarlet in early fall.

11. Monday, November 20.

Solanaceae. Scrophulariaceae. "Give me to drink mandragora * * *
That I might sleep out this great gap of time
My Antony is away."

Mandrake, henbane, bella donna, datura and nicotine are deadly narcotic poisons of the nightshade family which also gives man the potato, tomato, eggplant, sweet pepper and tobacco. Figworts include foxglove, yielding digitalin, a heart medicine, mulleins, snapdragons, calceolarias, the Empress tree and other plants of greenhouse and garden.

12. Monday, November 27.

Rubiaceae. Caprifoliaceae. Coffee, quinine and madder, which is used to color Edam cheese, belong to the madder family, which also contains our Quaker Lady, the dainty partridge berry and fragrant gardenia. In the caprifoliaceae the kinds of bush honeysuckle, Lonicera, are numerous and varied as are also the many species of Viburnum, which include our garden snowballs, and high bush cranberry. The elderberry is also in this group and the twin-flower named Linnaea in memory of Linnaeus, the immortal Swede.

13. Monday, December 4.

Cucurbitaceae. "When the wife of the great Socrates threw a teapot at his erudite head, he was as cool as a cucumber." Cucumbers, pumpkins, squash, cantaloupes, honeydew melons and watermelons are all gourds and the fruit is called a pepo. The flower contains either pistils or stamens but never both in the same flower, and the family botanically and popularly is filled with intense interest. Ornamental gourds exhibit a surprising variety of forms. A recently introduced vegetable in the group is the chayote.

14. Monday, December 11.

Compositae. That "wee crimson tippit flower" of Burns, the English daisy, and the mighty legion of its fellows form the Compositae, the largest family of flowering plants and the crown of the vegetable kingdom in bearing heads of many flowers in co-operation, producing fruits which have evolved ways to be disseminated that have made them successful in the struggle for existence. Chrysanthemum, dahlia, marigold, and daisy; lettuce, endive, artichoke and salsify; dandelion, thistle, burdock and beggars' ticks are but a few representatives of the great order of asters.

Field Trip

The class in Botany will be conducted on a field trip under the leadership of Professor Kaiser. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

INORGANIC CHEMISTRY 1

PROFESSOR HORN

General Principles. Notation. Nomenclature.

Lectures begin at 7.45 P. M.*

1. Tuesday, September 12.
   Scope of Chemical Science. Distinctions between physical and chemical change. Characters of chemical change (color, odor, solubility. Other changes in properties). Necessity for intimate contact for reacting bodies. Velocity of chemical change.
2. Tuesday, September 19.
   Definiteness of Chemical Action. Law of indestructibility of matter. Law of definite proportion. Idea of the elements, and of chemical compounds.
3. Tuesday, September 26.
   Atomic Theory. Law of multiple proportions. Atomic weights. Symbols and their uses. Complexity of the atom. Electrons.
4. Tuesday, October 3.
   Hydrogen. Occurrence, preparation, properties. Use as a standard. Industrial uses.
5. Tuesday, October 10.
   Oxygen. Occurrence, preparation, properties. Use as a standard. Industrial uses. Ozone. Allotropism.
6. Tuesday, October 17.
   The Common Properties of Gases. The gas laws; the general gas equation; the gas constant. The law of Gay-Lussac; Avogadro's hypothesis; molecular weights. The relation between atomic weights, chemical equivalents, and valence.
7. Tuesday, October 24.
   Molecular Theory. Formulas and their use. Representation of reactions by chemical equations. Complexity of molecules. Isomerism.
8. Tuesday, October 31.
   Chemical Forces. Law of chemical statics. Law of chemical kinetics. Historical views of chemical affinity. Chemical resistance. Valence. Transmutation of elements.
9. Tuesday, November 7.
   Water. Composition. Preparation of pure water. Decomposition by metals and non-metals. Hydroxids. Hydrates. Solutions. Importance to life. Heterogeneous equilibria and the phase rule. Hydrogen peroxid.
10. Tuesday, November 14.
    Electro-Chemical Phenomena. The tension series. Equivalence. Faraday's laws of electrolysis. Ionization. Strong and weak electrolytes. Neutralization. Indicators. Hydrolysis.

* Please note the hour.

11. Tuesday, November 21.

    Principal Types of Inorganic Compounds. Oxids. Anhydrids. Salts. Nomenclature. Acid salts and basic salts. Radicles. Double salts, molecular compounds, and complexes.

12. Tuesday, November 28.

    Physical-Chemical Phenomena. Catalysts. Colloids. Osmotic pressure. Active and inactive molecules. Dissociation.

13. Tuesday, December 5.

    Air. History. Composition. Modern ideas of the structure of the atmosphere. The "Noble" gases. Oxidation and reduction. Industrial uses of air. Modern views on ventilation.

14. Tuesday, December 12.

    Elementary Ideas in Energetics. Law of conservation of energy; second law of thermodynamics. Kinetic theory; Waal's equation; states of matter. Solid and liquid phases; growth of crystals; crystal lattices; Mitscerlich's law. Thermochemistry; principle of maximum work.

ORGANIC CHEMISTRY 1

PROFESSOR GRIFFITH

General Principles: Aliphatic Hydrocarbons and Derivatives

Lectures begin at 8 P. M.

1. Wednesday, September 13.

    Nature and Composition of Organic Matter. Distinctions between the terms organic and inorganic. 1828—Wohler's discovery of urea synthesis —and changed concepts of organic chemistry. The Dawn of Creative Chemistry.

2. Wednesday, September 20.

    The Composition of Organic Matter. Where Carbon is King. Proximate and ultimate analysis. General tests for organic substances.

3. Wednesday, September 27.

    Transformations of Organic Matter in Nature. Fermentation—Putrefaction—Decay. Nature's scheme of circulation. The "ups and downs" of nitrogen.

4. Wednesday, October 4.

    Transformations of Organic Matter in the Laboratory. Destructive distillation, fractional distillation, substitution of elements and groups. Organometallic compounds. Builders of molecular structures.

5. Wednesday, October 11.

    Industries Based upon Fermentations of Various Kinds. Alcohol, acetone, glycerol, acetic acid, lactic acid, citric acid. Tanning, brewing, food and dairy industries.

6. Wednesday, October 18.

    Classification and Nomenclature of Organic Compounds. A study in names. Diaminodihydroxyarsenobenzene hydrochloride vs. sodium chloride. Complexity of organic terms necessary; each syllable means something to those who "run and read."

7. Wednesday, October 25.

    Molecular Structure. Isomerism, polymerism, metamerism. Einsteinian chemistry—stereochemistry and optical activity.

8. Wednesday, November 1.
   Hydrocarbons. Principal types. Homologous series. Paraffins (methanes). Petroleum. Gasolines, cleaning fluids and solvents.

9. Wednesday, November 8.
   Paraffins (methanes) (Continued). Natural gas and its derivatives. Coal gas, bitumens, etc.

10. Wednesday, November 15.
    Olefins (ethenes). Derivatives of hydrocarbons. Alcohol radicles.

11. Wednesday, November 22.
    Alcohols. Ethyl and Methyl, the alcohol twins. Proof spirit, denatured alcohols, medicated alcohols, industrial alcohols. Other alcohols used in the arts and industries. Alcoholic beverages.

12. Wednesday, November 29.
    Aldehydes. Acetaldehyde, formaldehyde and their polymers. Their industrial applications.

13. Wednesday, December 6.
    Ethers and Esters. Scent and flavor owe their favor, mostly to these twins. Esterification, hydrolysis, saponification.

14. Wednesday, December 13.
    Esters (Concluded). Commercial uses of ethers and esters. Industrial solvents. The great lacquer industry. Imitation fruit flavors.

ENGINEERING 3

PROFESSOR WAGNER

Roads, Railroads and Tunnels

Lectures begin at 8 P. M.

1. Friday, September 15.
   Engineering Location. Surveying. Measuring straight lines. Measuring angles. Field work.

2. Friday, September 22.
   Engineering Location (Continued). Vertical measurements. The "Y" level. Barometer. Topography. Field work.

3. Friday, September 29.
   Roads and Pavements. Definition. Reconnaisance. Preliminary surveys. Maps. Profiles. Location.

4. Friday, October 6.
   Roads and Pavements (Continued). Earthwork. Drainage. Foundations.

5. Friday, October 13.
   Roads and Pavements (Continued). Surfacing. Natural dirt roads. Gravel roads. Broken stone roads.

6. Friday, October 20.
   Roads and Pavements (Concluded). Granite block, asphalt, wood and concrete pavements.

7. Friday, October 27.
   Railroads. Economic location. Railroad curves. Field work.

8. Friday, November 3.
   Railroads (Continued). Earthwork. Drainage. Ballast. Ties.

9. Friday, November 10.
   Railroads (Continued). Rails. Frogs. Switches. Crossings.

10. Friday, November 17.
   Railroads (Continued). Signals: block; interlocking. Turntables. Snow sheds and fences. Rolling stock and locomotives.

11. Friday, November 24.
   Railroads (Continued). Stations. Terminals. Bridges. Elevated railroads.

12. Friday, December 1.
   Railroads (Concluded). Underground railroads. Use of electricity. Street railways. Rack railroads.

13. Friday, December 8.
   Tunnels. Location. Shafts. Heading. Driving in soft ground; in rock. Blasting. Explosives. Ventilation.

14. Friday, December 15.
   Tunnels (Concluded). Cross sections. Packing. Submarine tunnels.

ZOOLOGY 2

PROFESSOR SCHMUCKER

The Backboned Animals

Lectures begin at 8 P. M.

1. Monday, January 8.
   The Origin of the Backbone. One of the real problems. The acorn-tongued worm may give the clue. The sea-squirts stranded on the way. The lancelet tells the clearer part of the story.

2. Monday, January 15.
   The Simplest Fishes. The lampreys are scarcely fishes. Sharks are old fashioned but successful. Their flattened cousins, the rays. Lungfishes and their promise.

3. Monday, January 22.
   Modern Varieties of Fishes. By adaptive radiation fishes have taken on many forms but the body plan remains the same. It is the basis for the whole vertebrate stem.

4. Monday, January 29.
   How Vertebrates Left the Water. From fins to legs. From swim bladders to lungs. The frogs take in their tails. Youth is a remembered ancestry.

5. Monday, February 5.
   Reptiles, Past and Present. The first backboned animals to live well on land. Their remarkable development. How snakes lost their legs and turtles spread their ribs. Change of climate curbed them.

No lecture February 12.

6. Monday, February 19.
   How Birds Sprung from Reptiles. Upright walking lizards. The link with the birds. Scales turn to feathers as warm blood comes in. Eggs are now incubated. The lowly ostrich.

7. Monday, February 26.
   Birds of our Neighborhood. Gulls of the shore. Swimming birds. The waders. The birds of prey. Woodpeckers. The perchers.

8. Monday, March 5.
   How Mammals Took to Giving Milk. Mammals, like birds, came from the reptiles. Fur as a warmth conserver. Eggs are hatched inside the body, and young fed there. Milk comes from the altered skin glands.

9. Monday, March 12.
   The Gnawing Animals (Rodents). Their long front teeth. The water-loving muskrats and beavers. Groundhogs, rabbits and chipmunks. The tree-loving squirrels.

10. Monday, March 19.
    The Hoofed Animals (Ungulates). Losing toes as ground hardens. Swine. The cud chewing animals. The horse and its one toe.

11. Monday, March 26.
    Predatory Animals (Carnivores). Big, tearing teeth. The bear and his flat foot. Shearing food instead of chewing it. The dog family and the pack. The lonely cats.

12. Monday, April 2.
    Mammals that Returned to the Water. Not confined to one family. Varying degrees of alteration. Otters at home on land and in water. Seals live best in water. Whales and sea cows confined to the water.

13. Monday, April 9.
    Mammals that Developed Hands (Primates). The result of taking to trees for food and safety. Fox-like lemurs. The two lines of monkeys. The big brained apes. Man.

14. Monday, April 16.
    The Mental Life of the Apes. Chimpanzee and Orang have been studied most. Their spontaneous activities. Purposeful action. Emotional life. What is reasoning?

Field Trip

The class in Zoology will be conducted on a field trip under the leadership of Professor Schmucker. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

GEOLOGY 3

PROFESSOR HOWELL

Paleontology

Lectures begin at 7.45 P. M.*

1. Tuesday, January 2.
   Paleontology, the Science Which Makes the Bones of the Dead to Live. How the science was born and grew to its present stature.

2. Tuesday, January 9.
   The Role of Paleontology in Modern Civilization. The cultural and economic influence of this young science.

3. Tuesday, January 16.
   How Paleontologists Learn What the Life of the Past Was Like. Fossils, and what can be learned from them.

4. Tuesday, January 23.
   How Paleontologists Classify the Knowledge They Have Gathered. How plants and animals are classified. Floras and faunas of the Past.

* Please note the hour.

5. Tuesday, January 30.
   The Causes and Course of Plant and Animal Evolution Through the Ages. The marvelous story of the growth of the "Tree of Life," and what we know of the influences which determined the manner of that growth.
6. Tuesday, February 6.
   How Did Life Begin on the Earth? What we think the earliest living things on this planet must have been like.
7. Tuesday, February 13.
   The Plants' Long Struggle to Gain a Foothold on the Land. How they finally succeeded in climbing out of the "Cradle of the Deep."
8. Tuesday, February 20.
   The Great Coal Forests of the Late Paleozoic Era. The somber forests whose fossilized remains we use to heat our homes and run our trains and factories.
9. Tuesday, February 27.
   The Gayer Plants of More Modern Times. The evolution of the flowering plants, and their rise to supremacy.
10. Tuesday, March 6.
    The First Many Celled Animals. The sponges and coelenterates.
11. Tuesday, March 13.
    The Animals Which Evolved from the Coelenterates. The worms and their varied descendants.
12. Tuesday, March 20.
    The Animals Which Put on Armor. The echinoderms, molluscoideans, and Mollusks.
13. Tuesday, March 27.
    The Animals with Many-Jointed Legs. The crustaceans, arachnids, and insects, and their relatives.
14. Tuesday, April 3.
    The Backboned Animals Which Now Dominate the Earth. The fishes, amphibians, reptiles, birds, and mammals. The paleontology of Man.

Field Trip

The class in Geology will be conducted on a field trip under the leadership of Professor Howell. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

PHYSICS 4

PROFESSOR SEELY

Electricity and Magnetism

Lectures begin at 8 P. M.

1. Wednesday, January 3.
   Stationary Electric Charges. How Man's knowledge of electricity began and grew. How charges are produced. Law of attraction and repulsion. Static machines. Condensers. Potential and capacity. Action of points. Lightning.
2. Wednesday, January 10.
   How Electric Currents are Caused and Controlled. Voltaic cells. An "electric current." Electro-motive force or pressure. Source of energy in cell. Local action. Polarization. Batteries. Open and closed circuit cells. Thermo-electric cells.

3. Wednesday, January 17.
   The Flow of Electricity in Circuits. Conductivity. Resistance. Pressure and amount of flow. Ohm's law. Electrical units. Specific resistance.

4. Wednesday, January 24.
   The Flow in Circuits (Continued). Resistance in wire circuits. Circuits in parallel and in series. Shunts. Fall in pressure along a circuit. Connection of cells in parallel and in series.

5. Wednesday, January 31.
   The Flow in Circuits (Concluded). Heat effects of the current. Electrical work and power. Conservation of energy. Relation of electrical units to those of heat and mechanical energy.

6. Wednesday, February 7.
   Electrolosis. The flow of current in liquid circuits. Chemical effects. Laws of Faraday. Chemical equivalent and electro-chemical equivalent. Voltameters.

7. Wednesday, February 14.
   Magnetism. The growth of our knowledge of magnets. Natural and artificial magnets. Law of magnetic attraction and repulsion. Molecular magnetism. Magnetic fields. Terrestrial magnetism.

8. Wednesday, February 21.
   How Magnetism and Electricity are Related. Effect of a current on a magnetic needle. Magnetic field produced by a current. Direction of lines of force in such a field. Coils and electro-magnets. Permeability and reluctance. The magnetic circuit.

9. Wednesday, February 28.
   Getting a Current of Electricity from a Magnetic Field. A conductor "cutting" lines of force. Magnetos. Direction and magnitude of induced pressure. Coils in a magnetic field. Induction coils. Lentz's law.

10. Wednesday, March 7.
    Instruments for Measuring Current and Pressure. Galvanometers. Voltmeters and ammeters. Wattmeters.

11. Wednesday, March 14.
    Measuring Resistances. Measurement by substitution. Resistance boxes. Wheatstone's bridge. Ammeter-voltmeter method.

12. Wednesday, March 21.
    How Current is Made and Used Commercially. Direct current dynamos and motors. Field magnets. Bi-polar and multi-polar machines. Armatures. Commutators. Series, shunt and compound windings for field magnets.

13. Wednesday, March 28.
    Some Differences Between Alternating and Direct Currents. Representation of alternating currents by curves. Self-induction. Measuring instruments for alternating currents.

14. Wednesday, April 4.
    Some Facts and Some Theories Concerning Electricity and Matter. Passage of electricity through gases. Radium and its products. Molecular constitution of electricity.

MUSEUM TALKS

Monday evenings at 7 o'clock

This series comprises informal talks, given on Monday evenings, illustrated by specimens in the Museum.

MR. LAWRENCE

The Small and Lowly Animals

Sept. 11. The Unseen Animals, Protozoa.
Sept. 18. Animals that are full of Holes, Sponges.
Sept. 25. Sea-anemones, Corals, and their Relatives.
Oct. 2. Worms—Round Worms, Flat Worms, Segmented Worms.
Oct. 9. Spiny-skinned Animals of the Sea.
Oct. 16. Soft Animals in Hard Shells.

PROFESSOR SCHMUCKER

Animals of Medium Rank

Oct. 23. Crabs and their Cousins.
Oct. 30. Slime Slugs and Centipedes.
Nov. 6. Hoppers, Dragonflies and Bugs.
Nov. 13. Flies, Beetles and Butterflies.
Nov. 20. Bees, Wasps and Ants.
Nov. 27. Spiders and Scorpions.

MISS BORDEN

Animals with a Backbone

Dec. 4. Vertebrates Living in Water.
Dec. 11. Learning to Live on Land. Creeping and Crawling.
Dec. 18. Feathered Vertebrates—Flying and Flightless.
Dec. 25. No lecture.
Jan. 1. No lecture.
Jan. 8. Curious Old-World Types.
Jan. 15. Fur-bearing Animals.
Jan. 22. Hoofs and Horns, and the Highest Mammals.

PROFESSOR HOWELL

Minerals, Rocks and Fossils

Jan. 29. The Minerals of which the Rocks are Composed.
Feb. 5. Sedimentary Rocks, which are Formed Layer upon Layer.
Feb. 12. No Lecture.
Feb. 19. Rocks which are Formed from Hot Liquids and Rocks which have been changed from their Original State.
Feb. 26. The Fossils which are Found in the Rocks—Plant Fossils.
Mar. 5. Invertebrate Fossils and the Paleontological Museum at the Bottom of the Sea.
Mar. 12. Vertebrate Fossils, Including Fossil Men.

PROFESSOR KAISER

Great Groups of Plants

Mar. 19. Rockrose and Violet Families. The Tea Plant, Camellia, Franklin-tree and delicious Mangosteen.
Mar. 26. Nettle Family. Elm, Hackberry and Mulberry. Stories of the luscious Fig, spreading Banyan and deadly Upas Tree.

Apr. 2. Buckthorn and Grape Families. Berry-bearing Alder and the ages-old history of the Grape, sacred to Bacchus.

Apr. 9. Heath Family. Plants that love acid soil. Blueberries and Huckleberries. Mountain Laurel and Rhododendron. Heather, Trailing Arbutus and True Arbutus, the Strawberry Tree.

Apr. 16. Ebony, Storax and Primrose Families. Persimmons and Trees that Produce Valuable Timber. The Lovely Storax. Cowslips, Primroses and Cyclamens.

Apr. 23. Olive and Gentian Families. The Olive, Ripe or Unripe, as Food for Man. Lilacs, Privets and Forsythias. The Ash. Beautiful Gentians of the Alps and Elsewhere. Our Fringed and Pine Barren Gentians.

GENERAL SCHEDULE OF REGULAR LECTURES

Subjects of courses in each of the four successive years constituting a full term.

ENGINEERING

1. Materials of Engineering Construction.
2. Civil Engineering Structures.
3. Roads, Railroads and Tunnels.
4. Water Supply, Sewers, Canals, Rivers and Harbors.

PHYSICS

1. Properties of Matter. Mechanics.
2. Heat and Sound.
3. Light.
4. Electricity and Magnetism.

INORGANIC CHEMISTRY

1. General Principles, Notation, Nomenclature.
2. Descriptive Chemistry.
3. Descriptive Chemistry.
4. Descriptive Chemistry.

ORGANIC CHEMISTRY

1. General Principles, Aliphatic Hydrocarbons.
2. Carbohydrates, Fats, Oils and Waxes.
3. Cyclic Hydrocarbons.
4. Compounds of Nitrogen.

ZOOLOGY

1. Invertebrate Animals.
2. Vertebrate Animals.
3. Human Biology.
4. Principles of Animal Life.

BOTANY

1. Morphology.
2. Taxonomy.
3. Taxonomy (continued).
4. Physiology and Ecology.

GEOLOGY AND PALEONTOLOGY

1. Physical Geography.
2. Physical Geology.
3. Paleontology.
4. Historical Geology.

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1912.—Ancient Civilization of Babylonia and Assyria. *Morris Jastrow, Jr., Ph.D.*
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1931.—The Problems of the Origin and Antiquity of the American Aborigines in the Light of Recent Explorations. *Aleš Hrdlička, M.D., Sc.D.*
1932.—Common Sense, Science and Philosophy. *John Dewey, Ph.D., LL.D.*
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Bulletin of the Institute. Quarterly $1.00 per year
Single numbers, 25 cents.

Republication of Conrad's Fossils of the Medial Tertiary of the United States. Introduction by *William H. Dall.* (Out of Print.)

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SYDNEY L. WRIGHT, JR., *Editor*

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SELECTIVE MATING AMONG SOLDIER BEETLES

By S. C. Schmucker

The Theory of Sexual Selection

It is very rarely that the propounder of a scientific theory leaves behind him the evidence of the steps in the growth of that idea in his own mind. This Charles Darwin did in his theory of "The Origin of Species by Means of Natural Selection."

Not only was the conception long in developing in the mind of its author, but during all that time he corresponded with many fellow scientists who valued his letters highly enough to preserve them.

Moreover, seventeen years (1842) before the publication of his great work, he committed to paper an abstract of thirty-five pages, written in pencil. One paragraph of about one hundred and fifty words shows the presence in his mind of the idea of sexual selection. Two years later (1844) he wrote much more extensively his conclusions, apparently only for the purpose of clearing the matter in his own mind. This time the sexual selection idea is more clearly shown to have occupied his attention, but not to have assumed the importance there it later acquired. It took up about one full page in a 230-page paper. Both of these accounts were for a long time lost to sight. They turned up later and in 1909 were published by his son Francis. In 1859 came Darwin's great book, on "The Origin of Species by Means of Natural Selection." In this book a section three pages long was devoted to sexual selection. Twelve years later (1871) he put out his volume applying the selection theory to "The Descent of Man," which question he had been criticized for neglecting. In this volume the subject indicated in the title occupied but one-third of the space. The remaining two-thirds, marked "Part II," was taken up with a special aspect of the selection theory. This portion he sub-titles "Sexual Selection." Over this part of the theory there has been a great deal of controversy. This is true, even among men who quite accept organic evolution, and who allow to natural selection no small part in determining the course of such evolution. They cannot accept the idea that the peculiar markings, or special organs, which distinguish the male from the female, but which play no actual part in the sex act in itself, receive any attention from the female. With the history of this controversy this brief communication can scarcely deal. It is hoped a later and more extensive paper will do so. Suffice it for the present to say that Darwin's arguments in its favor were partly theoretical, and largely based on scattered reports of observations made by very many workers. There was no attempt to observe the actual mating of any considerable numbers of any special species. Modern biology has become more largely statistical; but so far as I know, little has been done along this line among insects. The notable exception is the one recorded in Psyche (Vol. 9, pp. 15 20, 1900), by A. G. Mayer and C. G. Soule. These writers gathered in New England many cocoons of the promethea moth (*Callosamia promethea*) and took them to the Dry Tortugas Islands on the Florida coast, where this species is not found. Here is a highly colored moth, with the male quite unlike the female in general color and markings. The careful experiments of these workers show, I think, beyond question, that in this species neither sex pays any attention whatever to the color of the other. Whatever sex attraction is here shown seems to be entirely a matter of odor, which, in this species and its near allies, is unusually strong.

I should be inclined to accept this as proving from one species what might well apply to the whole order of Lepidoptera and perhaps to insects in general, were it not for the fact that this moth, as indeed most moths (*Heterocera*), fly by night, while the true butterflies, the more primitive section of the order (*Rhopalocera*), are day fliers. It would seem not impossible that, with the assumption of night flight, the colors, originally evolved for day purposes, had lost their significance, and the odor, clinging to both sexes, and doubtless serving for protection, had become intensified, and had taken over the added function of attraction of the mate.

The section of the Biological Abstracts for November, 1931, names a paper by G. Spet, published in the Memoirs of Science of the Ukraine, which it summarizes by saying that 156 pairs of *Coptocephala unifasciata* and 56 of *Anisoplia segetum*, taken copulating, showed no preference for any particular variations in structure. I have thus far not seen this paper.

Under the circumstances, it seems to me worth while to publish what follows.

GATHERING THE MATERIAL

On June 6, 1903, just before noon, on the campus of the State Normal School (now the State Teachers College), at West Chester, Pa., my attention was caught by a bush of *Deutzia scabra*. It was crowded with beetles. They were clearly closely allied with the fire-flies, though they were out in the day-time and had no light emitting power. I am certain they were either *Chauliognathus marginatus* (Fab.) or *C. pennsylvanicus* (DeG.), both of which are "Soldier Beetles," common to our locality. Frank E. Lutz, in his "Field Book of Insects," says, "adults of *marginatus* appear in spring and early summer while those of *pennsylvanicus* are autumn creatures." W. S. Blatchley reports having once found adults of *pennsylvanicus* mating in Indiana on June 30; he says most of the mating occurs "in autumn, on the goldenrod and similar species." I found this year (1933) many individuals of *pennsylvanicus* mating on the goldenrod on September 7. I have no doubt the species I had previously found was *marginatus*. The reason for any uncertainty will appear later.

The beetles were gathered chiefly on the flowers of the *Deutzia scabra*, though some were on the leaves. They seemed to be feeding on the pollen, though it is not unlikely that nectar formed a part of the meal. What attracted my attention particularly was the large proportion of these beetles that were joined in mating, and the fact that, on capture, they separated so slowly that there was no difficulty in catching the mating pair without either of them escaping.

To keep our material in identifiable shape, some of my students each took a cylindrical stick (what the cabinet maker knows as a dowel pin), about four inches long and three-eighths of an inch in diameter, and a sheet of writing paper about three inches square. The paper was wrapped about one end of the stick projecting for about half an inch beyond the end. The extended end of the paper was folded against the end of the stick, and then slipped off. This formed a paper cylinder, closed at one end. These cylinders were quickly made, and with a basket full of them we repaired to the *Deutzia* bush. The hour between 11:30 and 12:30 was fully occupied by several of us in capturing these beetles. We had about cleared the bush when the call to lunch made us desist.

Our method of operation was as follows: Taking a paper cylinder from the basket, we picked up a pair, or a single unmating beetle, just as they came. Each catch was dropped into a separate cylinder, whose end was pinched and folded. The filled cylinders were then thrown into another basket. All the papers we filled at that one time were placed in a separate container, appropriately marked. These beetles form what I am considering in this paper as Series 1.

Returning to our task the same afternoon, a good many mating pairs were again found and captured. We gathered all mating pairs on the bush, but no single beetles, at this time. These were put into a separate container and marked Series 2.

Two days later (time of day not recorded) the bush was found to be again harboring many beetles, many of them mating. This time again only mating pairs were gathered. We continued collecting until a hundred pairs had been gathered.

Bushes full of mating beetles, notably in this neighborhood rose beetles (*Macrodactylus subspinosus*), are not uncommon, and the infested bush would have claimed only passing attention were it not for the fact that there was a remarkable color variation among these soldier beetles. The general color of the body, including that of the folded front wings, is a yellowish gray. But these front wings (elytra), very conspicuous when folded over the membranous hind wings in lighting, showed the variations that attracted my attention. There was a longitudinal dark blotch on each elytron. In some cases this dark patch was found only at the distal end of the wing. But there was every degree of extent to this patch, from a slight tip only, to the full extent of the wing.

As my most intense interest in biology at that time (and indeed ever since) has been in evolution, and as I was much attracted by Darwin's theory of sexual selection, it seemed to me that here there was available material that might help to illuminate this interesting and much controverted hypothesis. At that time, if I had heard of any statistical or experimental observations bearing on the theory, they had not impressed me. All arguments, either pro or con, which I had heard or read, were almost entirely theoretical. Here, it seemed, was an opportunity to observe the objective working out of the process, if such selection there be.

MOUNTING THE MATERIAL

In preparing the material for observation and recording, glass plates, five by seven inches in size, obtained by cleaning the old film from discarded negatives, were used. A piece of cardboard was ruled vertically and horizontally with lines so spaced that their intersections would give one hundred guide points within the area of each glass plate, there being ten vertical rows of ten spots each. This cardboard was placed beneath the glass plate. Over each intersection of the crossed lines a small dab of mucilage was placed with a light paint brush, and a beetle was laid on the pasted spot. In this way each plate was furnished with one hundred specimens, so placed that any one could be indicated by number, without placing any numbers on the plates except the even hundred.

The mated beetles were thus mounted in alternate lines of males and females. After a glass plate had received its quota of beetles a strip half an inch wide was placed around the beetles on the plate. This served to lift a second glass plate, used as a cover, sufficiently to keep it from pressing on the beetles fastened on the lower plate. A binding strip of paper was fastened about the edge, holding the two plates and the intercalated cardboard border firmly together. Before binding the plates, date, series number and the serial number of the first and last beetle on each plate were written on the card board margin. In this way we secured a mount which was easily examined, from either side, and which should, with proper precautions, have been permanent.

Unfortunately the work had to be done by students working at odd hours. While we believed we were keeping the beetles protected from infestation, the result proved we were entirely mistaken in this matter.

Fortunately a full record of every beetle on every plate was made at once, showing whether it was male or female, mated or single, and the character of the dark marking on the wings.

All the work thus far was done by my assistant and by students under my direction. The mounted beetles and the record sheets were laid aside to await a future convenience with less pressure of work. Some years later, on my retirement, I began looking over the material I had accumulated, and found the package. The records were safe, but the beetles had "returned to dust." Thus, unfortunately, I have no corroborative evidence for my records. I think there is no question of the record, so far as it goes. There was no attempt to select beetles in capture. On the first day all present were taken, until the call for lunch took us away with a few still on the bush. On the second and third collections only mating pairs were taken. But at no time was any attention paid, during the capture, to the character of the wing markings. There was no attempt to arrange them in any order on the glass, except that mated pairs were kept side by side, and only those caught at the same time were on the same sheet of glass. There was enough difference in size between male and female to require no special skill in the placing. Because the dark patch on the wing varied from none (in a single case) to the entire length of the wing, it was impossible to be precise in the matter of placing borderline cases in my series. Those that showed any spot on the distal end of the wing were assigned to group 1 if the spot did not extend more than one-fourth of the way up. Those in which the spot extended more than one-fourth and not appreciably more than one-half of the length of the wing were considered as belonging to group 2. When the dark patch extended more than half way, but not more than three-fourths of the length of the wing, such individuals were placed in Group 3. The rest, where practically the entire length of the wing bore its dark patch, constituted group four.

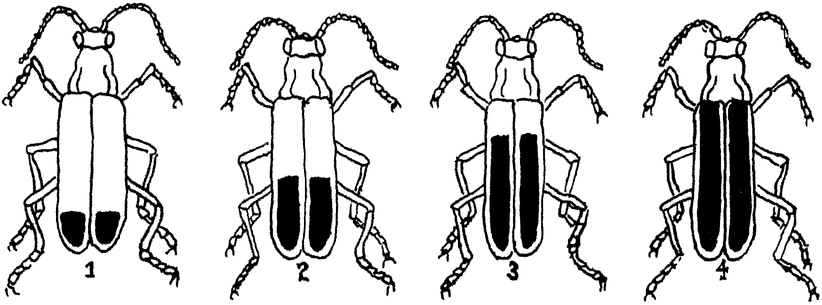

Fig. 1. The four groups of beetles.

Lately my connection with the Wagner Free Institute of Science has given me the opportunity and the stimulus to work up these records. The present publication in the Bulletin of the Institute is preliminary to a probable fuller account in the "Publications" of the Institute.

CONSTITUTION OF SERIES 1

Inasmuch as in gathering the beetles on June 6 about noon, all the beetles present on the bush (or very nearly all) were gathered, while in the case of those taken in the later afternoon, and of those taken two days later, only those found mating were captured, it is clear that series 1 gives material for some conclusions on which series 2 and series 3 give no evidence. Accordingly series 1 will first claim attention and our earliest conclusions will be drawn from this material alone. Later in the paper we shall see in how far the beetles gathered in the other two series strengthen or weaken the inferences drawn from the fuller first gathering.

In series 1, then, we find 451 individuals, of whom 238 (or 52.77%) are males, and 213 (or 47.22%) are females. It is interesting to remember that in his section on "Sexual Selection," printed with and forming the major part of the book entitled "The Descent of Man," Charles Darwin expressed the belief that for such selection to be effective there must be a larger number of males than of females of the species in the immediate environment. Later writers who favor the theory believe this not to be as necessary as Mr. Darwin stated, though naturally the excess of males would hasten the formation of special secondary sex characters peculiar to the male, should such modification be really due to sexual selection.

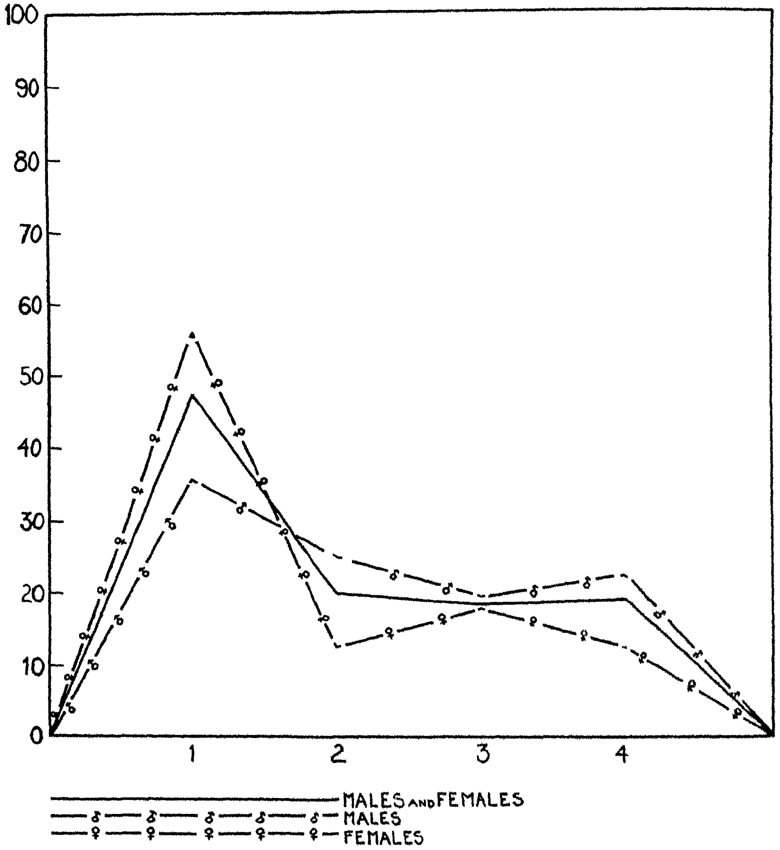

Fig. 2.--Percentage of beetles in each group.

(In the following tables, in working out percentages, the figure in the second decimal place was sometimes raised when the figure in the third place was greater than 5 and the percentage itself was high. This accounts for the fact that the percentages in every case total 100.)

INFERENCES FROM TABLE A

Of the beetles captured in Series 1, all but one have some amount of black patching on the wing covers. The solitary female which is without any such

SERIES 1, TABLE A.—NUMBER AND SEX OF BEETLES TAKEN

Group	Males		Females		Totals	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
1	87	36.55	119	55.87	206	45.68
2	56	23.53	29	13.61	85	18.85
3	42	17.65	37	17.37	79	17.51
4	53	22.27	27	12.68	80	17.74
O	0	0	1	.47	1	.22
Totals	238	100.00	213	100.00	451	100.00

dark patch failed to mate. When she appears in the tables, she is designated as O. Beetles with the distal end of the wing patched for one-fourth of the way up (Group 1) comprised a little less than half (45.68%). However, of the males little more than one-third (36.55%) are so patched, while more than half (55.87%) of the females fall into this group.

Those which make up Group 2, with the distal half of the wing blackened, form a little less than one-fifth (18.85%) of the whole. Here lie 23.53% of the males but only 13.61% of the females. In the third group, made up of those with from a half to three-fourths of the wing darkened, are found 17.51% of the whole. Here males and females are almost alike, males 17.65%, and females 17.37%. In Group 4, with wing from three-fourths to wholly darkened, are found 17.74% of all the beetles. Here there is again a contrast between the sexes, 22.27% of the males and but 12.68% of the females lying here. The solitary member of Group O is an unmated female, as before mentioned.

It would seem that the males as a whole trend towards the larger amount of coloration in the wings. From what I have gathered from observation of the beetles of this genus in the collection of the Academy of Natural Sciences in Philadelphia and in the Carnegie Institute in Pittsburgh, the less amount of coloration is much more common, and the fully darkened wings seem abundant only in *C. marginatus*—our species under consideration. If this be true, as is common in dimorphic coloration of the sexes of a species, it is the males that depart from and the females that cling to the probably earlier and now more common coloration of the genus. I hope at a later time to go more fully, and if it be possible to find materials enough, statistically, into this phase of the subject, and to give the results in the later and fuller presentation of the subject.

How the Various Groups Mated

Table B is intended to show what proportion of the mating was done by each color group of the beetles, both male and female. We will first consider the males. We found previously (Table A) that of the 238 male beetles 138, or 57.98%, had found mates. If mating were entirely a hit or miss affair, then, theoretically, these mating members should have been distributed through the four groups, at least approximately, in proportion to the number of male beetles belonging to each group. Examining Table B we find this not to be the case. While 57.98% of all male beetles mated, only 52.87% of Group 1 found mates. That is, members of Group 1 (those with the dark patch extending not more than one-fourth way up the wing) did only 91.18% the amount of mating which would seem to be their proper share. In other words, they failed by 8.82% to do their proportionate amount of the mating.

In similar fashion, we find Group 2 (with the dark patch covering one-fourth to one-half of the wing) falling still more strikingly behind their share. Only 44.64% of them mated when 57.98% should have done so, had there been no advantage or disadvantage in this pattern of coloring. Group 2,

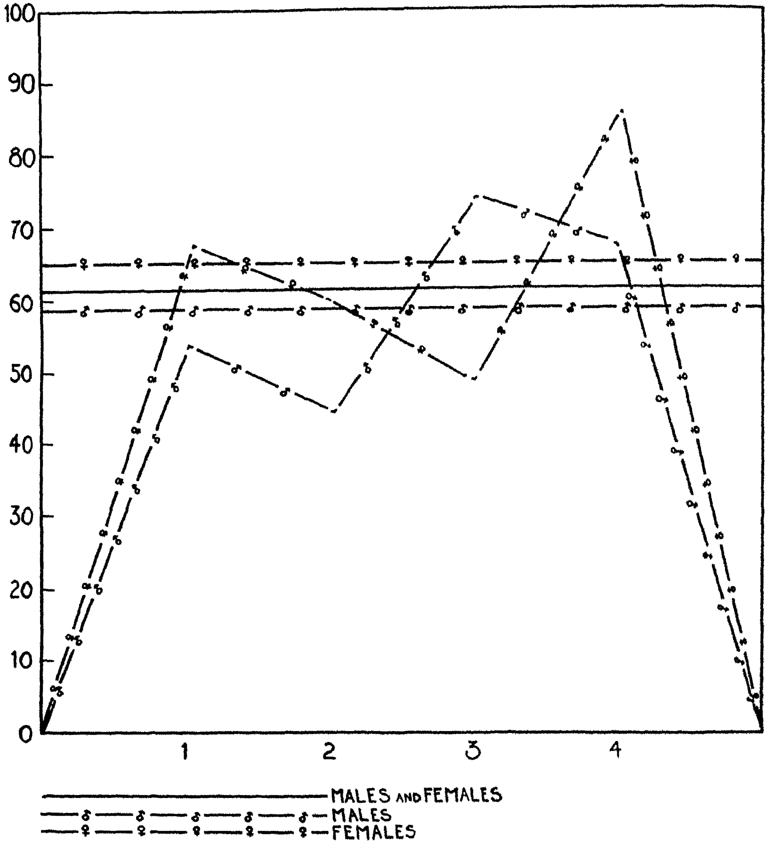

Fig. 3. The mating of the groups.

SERIES 1, TABLE B. –PERCENTAGE OF BEETLES MATING

Kinds	Per Cent Mating	Per Cent of Their Share of Mating	Per Cent above Their Share	Per Cent below Their Share
Males.				
All	57.98	100.00	. .	.
1	52.87	91.18	. .	8.82
2	44.64	76.99		23.01
3	73.00	143.15	43.15	.
4	67.93	117.16	17.16	.
Females.				
All	64.79	100.00	.	. .
1	67.23	103.77	3.77	. .
2	58.62	90.48	. .	9.52
3	48.69	75.15	. .	24.85
4	85.15	131.42	31.42	. .

then, mated only up to 76.99% of their expectancy; or, putting it otherwise, failed by 23.01 to do their share of the mating.

All this changes remarkably when we come to consider those with heavier wing colors. Of the males of color Group 3 (with from one-half to three-fourths of the wing darkened), 73.00% instead of the general average for all males of 57.98% found mates. This group did 143.15% of their expected mating; they did 43.15% more than their share.

In Group 4 (whose wings were from three-fourths to wholly blackened), again we find a high achievement in mating. They did 117 16% of their share of the mating. That is, they exceeded their share by 17.16%.

We find, then, that in the groups with lighter colored wings the males are far less successful than are the darker members who make up the two higher groups.

When we turn to the consideration of the mating of the females, we find a much less clearly marked condition of affairs.

As we saw in Table A, of the 213 females, 138 or 64.79% found males with whom to couple. Again, if color variations are without effect this same percentage should apply to each of the color groups. In Group 1 of the females (the lightest colored group), containing more than half of all the females, 67.23% of them found mates. That is, this group did 103.77% of its share of the mating; it departed from its natural share by only 3.77%.

Group 2 finds this reversed. But 58.62% of them mated. The group did only 90.48% of its expected mating; it failed of its expectancy by 9.52%.

The female members of Group 3, like those of Group 2, fall short. Only 48.69% (instead of 64.79%) mate. They do only 75.13% of their part; they fall short of their share in the mating by 24.85%.

In Group 4 (the darkest group) 85.15% (instead of 64.79%) found males with whom to couple. The group does 131.42% of its share of the mating; it does 31.42% more than, on hit or miss plans, it might be expected to do.

Here is a striking difference between the males and the females. In the males the lighter half is very distinctly less successful in mating. Darker wings seem to be of decided advantage to the male. Among the females, however, more than half of which lie in Group 1, the lightest group, this group has but little more than average success (3.77%). The remaining half of the females are fairly evenly distributed through the other three groups. Group 2 and Group 3 are quite unsuccessful, while Group 4 (the smallest group of females) is very successful. This seems quite irregular, while the result in the males shows a very definite trend. It appears to me that these facts point to the conclusion that:

1—It is the males that are selected, or at least accepted, by the females.

2—There is a tendency for the females to mate with the males of the groups which depart most widely from what seems to be the primitive color of the genus.

A later study will show in detail the comparative success of each group of the males with each group of the females.

SUMMARY

I think we may come to the following tentative conclusions:

1—The tendency of the coloration in the Genus *Chauliognathus* seems to be toward a progressive darkening of the front wings; *C. marginatus* carrying this trend farther than most, if not all, the remaining species of the genus.

2—This darkening is more marked in the males.

3—It brings a larger proportion of mating success to the darker males.

4—It would seem that mild selective or at least acceptive power lies with the females.

West Chester, Pa., October 28, 1933.

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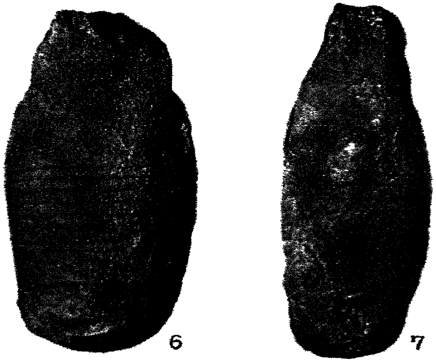

Gomphoceras grandtowerensis Branson and Williams
Page 158.

Figs. 6 and 7. Two views of the holotype. (X [illegible])
(Grand Tower limestone.) (W. M. 23897.)

ACLEISTOCERAS GRANDTOWERENSE (Branson and Williams) 1924.

Branson, E. B., and Williams, J. S., Missouri Bur. Geol. and Mines, ser. 2, vol. 17, p. 158, pl. 37, figs. 6,7, (1922).

Original Description

Gomphoceras grandtowerensis n. sp.

Plate 37, figures 6 and 7.

Description—Shell of medium size, nearly straight; transverse section oval; plane of greatest diameter the chamber adjoining the living chamber. Living chamber with the sides convex and contracting gradually to a place 22 mm. from the base. From this constricted band outward the sides are nearly straight. The aperture is [illegible] oval. The average depth of the air chambers is 4 mm. 14 chambers are preserved in the type specimen and there is little difference in their depth. The septa are slightly curved backward on the less convex surfaces. Siphuncle not observed. The [illegible] is remarkable for its symmetry.

Occurrence—Grand Tower limestone of Little Saline Creek.

Type Data: Holotype, 23879, Walker Museum.

Type Locality: Little Saline Creek, Missouri.

Occurrence: Grand Tower limestone, Little Saline Creek, southeastern Missouri.

Card prepared by A. K. Miller, State University of Iowa.

Published by Wagner Free Institute of Science.

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AN ILLUSTRATED CARD CATALOGUE OF NORTH AMERICAN FOSSILS

By B. F. Howell

The naming of the different kinds of plants and animals which was begun by Adam in the Garden of Eden has been going on ever since. Biologists have worked out a system of Latin nomenclature which indicates the evolutionary relationships of the different species, genera, families, orders, and classes of the living forms, and paleontologists have used the same system in naming the extinct ones whose fossils have been discovered. Tens of thousands of living animals and plants familiar to men throughout the world have received vernacular names in hundreds of languages and dialects. All these, and many more scores of thousands of existing species known only to biologists, have been classified and given scientific names by botanists and zoologists during the past 200 years. Students of the life of the past have named and classified many thousands more. The scientific names of all these species and genera now include more different words than are to be found in even the most complete dictionary of purely English terms.

Now, names are only appellations for things, and they are useful to those who employ them only in so far as the users comprehend or visualize the things to which the names belong. It is obvious that no one can remember the hundreds of thousands of names that have been given to the known kinds of living and extinct animals and plants or recollect their forms and features. No single man could possibly remember all the names of even the extinct species. Indeed, even a specialist in a restricted field of paleontological research cannot remember the names of *all* of the kinds of fossils with which he has to deal, unless his field is a very restricted one. And no investigator, no matter *how* small his field, can carry in his mind all the details of structure, and of the geographic and time ranges, of the species which he must use in his daily work. He must depend either upon examples of the various species preserved in museums, or upon pictures and descriptions of them printed in books, to refresh his memory and give him the information which he needs.

Fossils are to be found over much of the land surface of the earth. They have been collected by thousands of different people, stored in hundreds of different museums, and described in thousands of books and magazines, printed in more than a dozen different languages. Often a newly discovered species has been figured and described only once, and then in a book or a number of a periodical which is now so rare as not to be easily accessible to most investigators; and the specimen, or specimens, on which the description was based may be stored in a museum on the other side of the earth from the investigator who needs to know its characters, or even have been lost to view entirely.

Even in the case of the continent of North America and its adjacent islands, where only four languages—English, Spanish, French, and Danish—are commonly spoken and written, there have been found and described many thousands of fossils; these have been stored in so many museums at home and abroad, and their pictures and descriptions have been published in so many tongues, that it is practically impossible for most paleontologists to consult all the museum specimens or the literature that they *ought* to consult in order to do their work properly. The older workers have too often been forced to lower the standards of their research work because of this difficulty, and young men and women have been discouraged from devoting their lives to a science in which they would be so handicapped by the difficulty of securing essential information. Students of fossils have in recent years been getting more and more mired in the slough of paleontological literature, and the progress of their science has been increasingly hampered as the volume of literature has increased because no adequate plan had been perfected for making all of it available to the individual worker.

Realizing that something had to be done about this problem, paleontologists have for some time been discussing ways and means of solving it. Efforts have been made to increase the collections of the museums so that as many species as possible would be represented in each museum; but the number of known species of fossils is so great, and examples of many of them are so rare, that this has not proved to be a feasible solution. Monographs have been written, describing all the known species of fossils of some one family, order, or class, or of some one epoch or period or region. These have proved very useful; but they have soon become out of date, and it has seldom been possible to keep them abreast of the discoveries of the day. The only plan which has seemed likely to prove practicable is one which involves the printing on cards of figures and descriptions of the fossils and the filing of those cards in such a way that the files can be kept up to date. This, which may be kept abreast of new discoveries as no other can, has been adopted.

Some years ago a committee was appointed by one of the international geological congresses to undertake the preparation of cards of this sort. This committee has been issuing cards for the fossils of Europe. More recently the Paleontological Society, the international organization to which most of the paleontologists of North America belong, has begun the work of preparing and issuing cards for the fossils of this continent. It plans to publish first cards for the Devonian invertebrates. This work has been placed in the hands of a committee, of which Dr. E. M. Kindle, of the Geological Survey of Canada, is chairman. The Wagner Free Institute of Science has undertaken to publish the cards. Specialists from among the investigators best qualified to prepare the cards have generously volunteered their services, and the work is now well under way. The first unit to be completed will be that dealing with the cephalopods. The cards covering this class will therefore be the first to be published. It is expected that this unit, which will cover the Devonian ammonoids, will appear in the fall. It is being prepared by Professor A. K. Miller, of the University of Iowa.

The cards of this "Illustrated Catalogue of the Devonian Invertebrates of North America" will measure 8½ x 11 inches, so that they can be filed in a standard letter file. They will be printed on tough, heavy paper. Each card will bear one or more figures of the original type specimen, or specimens, of a species of Devonian invertebrate whose fossils have been found in North America, together with a printed description of the species, and information concerning its known time and geographic ranges, and the place of preservation of its original type specimens. The figures will be printed by the Full-Tone Collotype process.

The scientific value of these cards will be to a considerable degree proportionate to the opportunities which the specialists who prepare them have to examine the original specimens on which the various species were based and to prepare accurate figures of those specimens. All the money received from purchasers of the cards beyond what is required for actual printing and distribution will be used to enable the specialists to visit the museums where such specimens are preserved and to secure accurate pictures of them. Much of the information on the cards will therefore be new or more accurate than any now available in the literature.

Bibliographic indexes citing all important references to the fossils illustrated and described by the cards are also being prepared to accompany them. The index which will accompany the ammonoid cards is being prepared by Dr. Kindle and Professor Miller. It will constitute the first unit of a "Bibliographic Index of North American

Invertebrate Devonian Fossils," which it is hoped will be published by the Geological Society of America. When complete, this Index will contain bibliographic references to all important papers dealing with North American Devonian invertebrates. It will present a revised and stabilized nomenclature, and will give the known time ranges and geographic distribution of all the species. The first part of the Index to be published—that dealing with the ammonoids—will include a list of the Devonian formations of North America, with information about the exact age and known geographic extent of each one. Such an index has long been needed by paleontologists.

The preparation of this illustrated card catalogue and bibliographic index is one of the most ambitious pieces of work ever undertaken by paleontologists of any continent. The catalogue and index will be historic landmarks on the highway of paleontological progress, and will, it is hoped, set the standard for future work of the same sort. Certainly they will place in the hands of future paleontologists tools of their trade which will save them countless hours of searching through the literature, and should enable them, and it is hoped will encourage them, to do more and better original research work.

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Republication of Conrad's Fossils of the Medial Tertiary of the United States. Introduction by *William H. Dall.* (Out of Print.)

BULLETIN
of the
WAGNER FREE INSTITUTE OF SCIENCE OF PHILADELPHIA

PUBLISHED BY THE INSTITUTE
SYDNEY L. WRIGHT, *Editor*

Vol. 9	Quarterly	$1.00 per year
No. 2	May, 1934	Single numbers, 25 cents

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BOVICORNELLUM VERMONTENSE, A PECULIAR NEW CAMBRIAN FOSSIL FROM VERMONT*

By B. F. Howell

In their attempts to learn how the rocks of the earth's crust are arranged and what their past history has been, so that this knowledge can be used to make the lives of their fellow men richer, safer, more comfortable, and happier, geologists and paleontologists have learned that fossils, in addition to being of great interest in themselves as remains of the life of the Past, afford much evidence of the age of the rocks in which they occur and of the ancient geography of the regions in which those rocks were formed. All fossils give useful evidence of this sort to the scientist, but some fossils are much more useful for this purpose than others. This is especially true of fossils which are abundant and easy to find, and which enable the geologist to tell at a glance the age of the rocks in which he discovers them.

In northwestern Vermont there is a belt of rocks of Cambrian age—some 400,000,000 to 500,000,000 years old— whose mode of origin and age are now being studied. Some of these rocks contain many fossils which prove that the rocks originated as sands, gravels, muds, and limestone reefs in a great arm of the sea which washed over that part of the world in Cambrian times, and also tell when these deposits were laid down on the sea bottom. Others of the rocks of the region hold few fossils, or none, and the geologists who have been studying them have had great difficulty in determining their origins and ages and their stratigraphic boundaries and relationships. These difficulties have been increased by the facts that a number of these rock formations which are of different ages look so much alike lithologically that they can not be told apart by their appearance, and that these similar appearing formations have been pushed over each other by thrusting since they were originally formed, the crust of the earth in this region having been since Cambrian days folded into a mountain range and the rocks much shoved westward.

One of the formations of this belt which has been hardest to identify and delimit is the Highgate Shale, which is shown by its fossils to be of Late Cambrian age, but which so much resembles one of the Middle Cambrian and one of the Lower Cambrian formations which are associated with it that geologists have been having great difficulty in recognizing it and mapping it in the field. Recent careful studies of this formation have disclosed the fact that at most places where large outcrops of its lower 100 feet of shale are exposed painstaking search is generally rewarded by the discovery of at least a few examples of a very peculiar little fossil, which is found in those beds and nowhere else, and which consequently is of great value as an index fossil.

This little fossil is shaped like a somewhat twisted cow's horn. Nothing just like it, or even closely resembling it, has ever been

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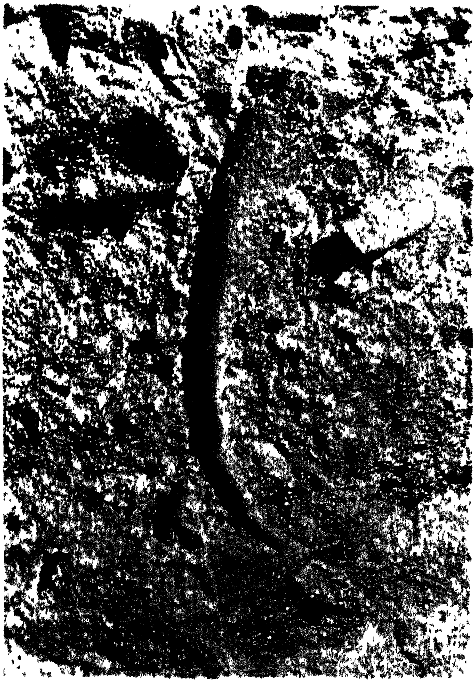
* A preliminary announcement concerning this fossil is being published in the Proceedings of the Paleontological Society for 1933, now in press.



Bovicornellum vermontense, n. sp. x 4

found in other rocks anywhere, as far as the writer has been able to learn. For this reason, and because of its value to students of the Cambrian stratigraphy of Vermont, it seems desirable that the fossil should be described and given a name. This is therefore done herewith.

The shape of the fossil is shown in the figure. None of the original shell or soft parts of the animal whose hard covering once occupied the little tubes which now give evidence of the creature's former existence are preserved. There are only the tubular hollows in the shale. As the walls of these tubes are smooth, no indication of the phylum or class to which the animal belonged can be gotten from that source.

As no living or extinct animals with tubes of just the sort that must have been possessed by *Bovicornellum vermontense* are known, it is impossible for us to be certain what kind of an animal the little creature was. Probably it was some kind of a worm, but it may possibly have been a mollusk. As trilobites and brachiopod fossils are found associated with its remains, it is certain that it lived in the sea. Whether it swam, lay or crawled on the bottom, or buried itself in the mud, we do not know, for the cavities which it has left in the shale lie at all angles to the bedding.

It is possible that this fossil should be assigned to a new family, as well as to a new genus and species; but, until this description of it has been distributed to paleontologists throughout the world, and the writer has had an opportunity to hear from them whether they know of any previously described and classified fossil to which this one may be related and with which it may be classified, he prefers not to erect a new family for it.

The characters of the new genus, *Bovicornellum*, are, as far as they can now be given, those of its genotype and single species.

The holotype of *B. vermontense* is no. 41155a in the Paleontological Collection of Princeton University. Paratypes are nos. 41155b+ and 41198–41209 in the same collection, and 89883 in the U. S. National Museum, 6462 in the Canadian National Museum, 24215 in the American Museum of Natural History, 13442 in the Peabody Museum of Natural History of Yale University, M.C.Z. 1009 in the Museum of Comparative Zoology of Harvard University, 15984 in the Museum of the Wagner Free Institute of Science, and 2.3500 in the Redpath Museum of McGill University. Tophomeotypes have been deposited in the Museum of the University of Vermont.

The holotype was collected from a bed of shale near the base of the Upper Cambrian Highgate Formation about one mile south of Parker's Hill in Georgia Township, Franklin County, Vermont; and all the other specimens of the species that have been collected were found in similar shale in the lower 100 feet of that formation in outcrops between a point one mile southwest of West Georgia, Franklin County, and the southern bank of the Missisquoi River between Swanton and Highgate Falls, in the northern part of the same county. This is the most abundant and useful index fossil found in the lower part of the Highgate Formation.

PUBLICATIONS OF THE INSTITUTE

TRANSACTIONS

Vol. 1.—Explorations on the West Coast of Florida and in the Okeechobee Wilderness. *Angelo Heilprin.* $2.50

Vol. 2.—Report on Fresh-water Sponges Collected in Florida. *Edward Potts.*
Notice of Some Fossil Human Bones. *Joseph Leidy.*
Description of Mammalian Remains from Rock Crevice in Florida. *Joseph Leidy.*
Description of Vertebrate Remains from Peace Creek, Florida. *Joseph Leidy.*
Notice of Some Mammalian Remains from Salt Mine of Petite Anse, Louisiana. *Joseph Leidy.*
On Platygonus, an Extinct Genus Allied to the Peccaries. *Joseph Leidy.*
Remarks on the Nature of Organic Species. *Joseph Leidy.* $1.00

Vol. 3.—Parts 1, 2, 3, 4, 5, 6.—Contributions to the Tertiary Fauna of Florida. *William H. Dall.* $15.75

Vol. 4.—Fossil Vertebrates from the Alachua Clays, Florida. *Joseph Leidy.* $1.25

Vol. 5.—Study of Hawaiian Skulls. *Harrison Allen.*
Notes on the Palæontological Publications of Prof. William Wagner. *William H. Dall.* $1.00

Vol. 6.—Selenodont Artiodactyls of the Uinta Eocene. *William B. Scott.* $1.00

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HISTORICAL NOTE

The Wagner Free Institute of Science owes its establishment to the liberality and public spirit of William Wagner and his wife, Louisa Binney Wagner. In his early life Professor Wagner made extensive voyages in the service of Stephen Girard, and had opportunities to visit scientific institutions and make the acquaintance of scientific workers. He soon developed a strong interest in the natural sciences, especially geology and mineralogy, and devoted a large part of his life to studying these topics and collecting material to illustrate the teaching of them.

In 1847 he began to give free lectures at his home, near the present location of the Institute building, at that time in the rural section of the county. In 1855 the Institute was incorporated by the Legislature, a faculty was appointed and lectures were given at Commissioners' Hall, Thirteenth and Spring Garden Streets, by permission of the city authorities. In a few years the city was obliged, by its own needs, to withdraw the privilege of the hall, and Professor Wagner arranged to erect a suitable building on his own property. This was completed in May, 1865, and lectures at once given in it. In 1864 a deed of trust was executed by Professor Wagner and his wife, furnishing a permanent endowment of the Institute.

In 1885, by the death of the founder, the care of the Institute passed into the hands of a Board of Trustees, since which time many improvements have been made in the building, and extensive additions to the equipment in the museum and library and in scientific apparatus. In 1901 a wing was built for the use of a branch of the Free Library of Philadelphia.

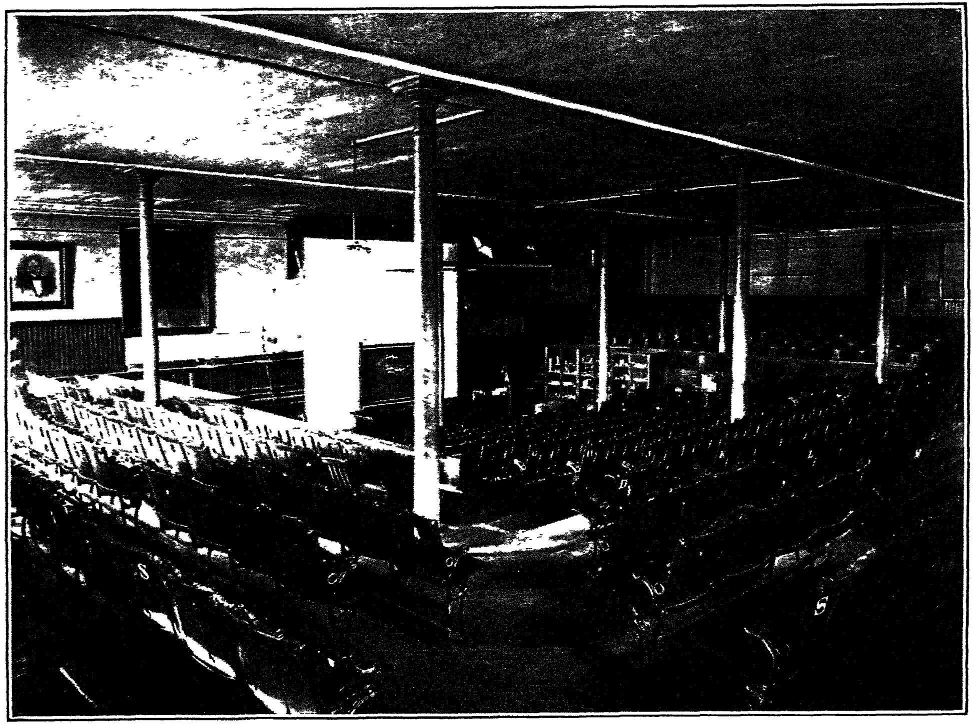
FACILITIES FOR INSTRUCTION

Lectures and Class-Work

Instruction at the Wagner Free Institute of Science is conducted by means of public lectures, supplemented by class-work, and is without charge and without restriction of race or sex. The class-instruction is given partly at the close of each lecture, partly by written exercises. The Museum and Reference Library of the Institute are available for aid in the instruction work and are freely used. In addition, the Wagner Institute Branch of the Free Library of Philadelphia affords abundant opportunities for collateral reading.

At the close of each course of lectures an examination is held, to which those who have attended the classes are admitted, and on passing such examination the pupil is awarded a certificate. Certificates are awarded at a public meeting held in May of each year.

The lecture courses are arranged to cover a given topic in four



AUDITORIUM

Museum

successive years, and to those who hold certificates for each of these courses a full-term certificate is issued.

Museum

The Museum covers the whole field of natural science and contains illustrations in all departments of biology, geology, mineralogy, metallurgy, and engineering. The specimens are arranged so as to be easily studied and are open to inspection from 2 to 5 o'clock Wednesday and Saturday afternoons, except legal holidays.

Teachers with classes and others desiring to use the museum for special studies can, by applying at the office, gain admission any week-day, except holidays, as above stated, between the hours of 10 A. M. and 5 P. M.

The collections of the museum have been used for a number of years for instruction by means of "Museum Talks," as noted below, and by arrangement with work at Temple University and the Division of Science Teaching of the Board of Public Education those teaching General Science in the eighth and ninth grades of the Philadelphia public schools or preparing for such teaching may secure elective credits upon the completion of the work as follows:

General Science II

Monday,	7 P. M. to 8 P. M.	Museum Lecture.
	8 P. M. to 9 P. M.	Lecture Course—Botany and Zoology.

NOTE: Four semester hours of credit will be given for the complete Monday evening program.

Tuesday,	7.45 P. M. to 9 P. M.	Lecture Course—Inorganic Chemistry and Geology.
Wednesday,	8 P. M. to 9 P. M.	Lecture Course—Organic Chemistry and Physics.

NOTE: An additional two semester hours of credit per evening may be obtained by electing Tuesday or Wednesday evening.

Monday evening is a prerequisite for these, however.

Further information concerning these courses may be obtained at the Office of the Institute.

Libraries

The Reference Library contains text-books and works of reference in all departments of science, encyclopedias, many works devoted to literature, and an assortment of dictionaries of English, classical and foreign languages. It is open on all regular business days from 10 A.M. to 9 P.M., a librarian being in attendance to assist students.

The Circulating Library is a branch of the Free Library of Philadelphia. Books may be taken out under the usual rules of the Free Library. Many periodicals—American and foreign, scientific and literary—are on file.

BULLETIN

The BULLETIN of the Institute is quarterly. It contains information as to the methods of work of the Institute, announcements of additions to its collections and original contributions to science. The ninth volume is now in course of publication. The subscription price is $1.00 per year, single copies, 25 cents.

SPECIAL LECTURES

By the liberality of Richard Brodhead Westbrook, D.D., for many years a trustee of the Institute, and of his wife, Henrietta Payne Westbrook, provision has been made for lectures independent of the general courses of the Institute and covering a wide range of topics. A list of lectures so far given and of publications thereof so far as issued is printed on page 133.

Announcement of the course for 1935 will be made in a subsequent issue of the BULLETIN.

The income of a fund given by Dr. Henry Leffmann is applied to providing special lectures as the Fannie Frank Leffmann Memorial Lectureship.

The *Philadelphia Natural History Society* meets on the third Thursday of each month, except June, July and August. These meetings are open to all persons interested in the subjects.

RESEARCH

The Institute has carried on research work since 1885, most of the results having been published in its Transactions and Publications. A list of these will be found on page 134. Results of research appear also from time to time in the BULLETIN.

The Henry Leffmann Chemistry Research Fund has been established for perpetual service.

CLOSING EXERCISES

In May of each year the courses of instruction are formally closed by a public meeting at which addresses are given and the certificates awarded.

At the closing exercises in May, 1934, after an address by Professor S. C. Schmucker, Dean of the Faculty, and awarding of certificates, Dr. H. C. Bryant, Assistant Director, National Parks Service, delivered a lecture entitled, "Scientific Features of the National Parks."

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Bernard Zitin

FACULTY

SAMUEL CHRISTIAN SCHMUCKER

A.M., M.S., Sc.D., Muhlenberg College.
Ph.D., University of Pennsylvania.
For thirty years Professor of Biological Sciences, State Teachers College, West Chester, Pa.
For twenty years head of Science Department, Summer Schools, Chautauqua, N.Y.
For fifteen years Lecturer on Biology, Brooklyn Institute of Arts and Sciences.
Professor of Botany, Wagner Free Institute of Science, 1908–1926.
Professor of Zoology, Wagner Free Institute of Science, 1926 to date.
Dean of the Faculty.
Author of
  "The Study of Nature." (Lippincott Co.)
  "The Meaning of Evolution."
  "Man's Life on Earth."
  "Heredity and Parenthood." (Macmillan Co.)

JOHN WAGNER, JR.

B.S. in C.E. 1913, University of Pennsylvania.
C.E. 1920, University of Pennsylvania.
Assoc. M., Am. Soc. C. E.
1913–1916, Draftsman, Phoenix Bridge Company.
1916–1921, Office of Engineering Bridges and Buildings, Pennsylvania Railroad, including two years' service with the Army as First Lieut. and Captain in the Cavalry.
1921–1926, Assistant Supervisor Track, Reading Company.
1926–1928, Supervisor Track, Reading Company.
1928 to date, Industrial Agent, Reading Company.
Professor of Engineering, Wagner Free Institute of Science, 1926 to date

LESLIE BIRCHARD SEELY

Graduate, State Normal School, Bloomsburg, Pa.
Taught school, Luzerne and Snyder Counties, Pa.
Assistant instructor in physics and chemistry, Bloomsburg, 1899–1902.
Graduate, Haverford College, 1905.
Head Master, Friends Institute, Chappaqua, N. Y., 1905.
Instructor in physics, Northeast High School, Philadelphia, 1906–1915.
Head of Science Department, Germantown High School, 1915–1923.
Principal, Roxborough High School, 1923–1924.
Principal, Germantown High School, 1924 to date.
Graduate courses, University of Pennsylvania and Brooklyn Institute, 1906–1910.
Honorary degree of Doctor of Pedagogy, Ursinus College, 1926.
Professor of Physics, Wagner Free Institute of Science, 1912 to date.
Publications:
  "Description of Two New Distomes," Biological Bulletin, Lancaster, Pa., 1906.
  "Ether Waves and the Messages They Bring."
  "The Physics of the Three-electrode Bulb," Transactions of the Wagner Free Institute of Science.

DAVID WILBUR HORN

A.B., Dickinson College, 1897.
A.M., Dickinson College, 1898.
Ph.D., Johns Hopkins University, 1900.
Assistant in Chemistry, Johns Hopkins University, 1900–1901.
Associate and Associate Professor of Chemistry, Bryn Mawr College, 1901–1907.
Lecturer in Hygiene, Hahnemann Medical College, 1911 to date.
Head of Pre-Medical School of Science, Hahnemann Medical College, 1916–1921.
Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science, 1921 to date.
Professor of Inorganic and Physical Chemistry, Wagner Free Institute of Science, 1911 to date.

Chairman of Philadelphia Section of American Chemical Society, 1904 and 1905.
Fellow of American Association for the Advancement of Science.
Fellow of the Royal Society of Arts of London.

IVOR GRIFFITH

Early education at the Bethesda Academy, Wales, and came to America in 1907.
P.D., Philadelphia College of Pharmacy and Science, 1912.
Ph.M., Philadelphia College of Pharmacy and Science, 1921.
Sc.D. (Hon.), Bucknell, 1934.
Director of Research, John B. Stetson Company, 1925 to date.
Director of Laboratories, Stetson Hospital, 1916 to date.
Editor, American Journal of Pharmacy, 1921 to date.
Associate Professor of Pharmacy, Philadelphia College of Pharmacy and Science, 1914 to date.
Professor of Organic Chemistry, Wagner Free Institute of Science, 1926 to date.
Secretary of the Faculty of Wagner Free Institute of Science.
Fellow of the American Institute of Chemists.
Fellow of the American Association for the Advancement of Science.
Fellow of the Pennsylvania Academy of Science.
Publications:
    "Recent Remedies," 1926 (revised 1928).
    "Popular Science Lectures" (Editor) (eight volumes).
    U. S. Dispensatory (Collab. Editor).
    Formula Book, A. Ph. A. (Editor).
    Contributor to current chemical, pharmaceutical and medical literature.

GEORGE BRINGHURST KAISER

Educated in private schools.
Graduate, Franklin School.
After graduation spent several years in intensive botanical study and field work in northeastern United States.
Secretary of the Botanical Society of Pennsylvania for seven years and leader of its field trips.
Professor of Botany, Wagner Free Institute of Science, 1927 to date.
Curator, Moss Herbarium, Sullivant Moss Society.
Treasurer, Delaware Valley Naturalists' Union.
Member, Academy of Natural Sciences.

BENJAMIN FRANKLIN HOWELL

B.S., A.M., Ph.D., Princeton University.
Associate Professor of Geology and Paleontology, Princeton University.
Professor of Geology and Paleontology, Wagner Free Institute of Science, 1927 to date.
Curator of Invertebrate Paleontology and Stratigraphy in Princeton University.
Fellow of the Paleontological Society.
Secretary of the Paleontological Society.
Fellow of the Geological Society of America.
Fellow of the American Association for the Advancement of Science.
Member of the Palaeontologische Gesellschaft.
Associate Member of the Society of Economic Paleontologists and Mineralogists.
Member of the Committee on Micropaleontology of the National Research Council.
Chairman of Cambrian Subcommittee of U. S. National Research Council Committee on Stratigraphy.
Secretary of the Organization Committee of the International Paleontological Union.
Editor of the section of General Paleozoology of *Biological Abstracts.*
American Editor of *Palaeontologisches Zentralblatt.*
Specializes in Cambrian Paleontology and Geology.
Associated with U. S. Geological Survey, the U. S. National Museum, Geological Survey of Canada, Canadian National Museum, Geological Survey of Vermont, Geological Survey of Montana, Colorado School of Mines, as a consulting paleontologist and research associate.

REGULAR LECTURES, SESSION OF 1934–1935

BOTANY 4

PROFESSOR KAISER

Physiology and Ecology

Lectures begin at 8 P. M.

1. Monday, September 10.

   How plants get their food from the necessary elements. The physics and chemistry of plant life. Cardinal points of growth.

2. Monday, September 17.

   How plants get carbon from the air. The necessity of leaf green in maintaining life upon the earth. The story of starch and its derivatives and of enzymes and their uses.

3. Monday, September 24.

   How plants get their nitrogen. How parasites, saprophytes and symbionts live. The helpful nitro-bacteria. The story of flesh-eating plants.

4. Monday, October 1.

   How plants breathe. Respiration contrasted with photosynthesis. How breathing in plants produces heat and light. Details of growth and development and the great age of trees.

5. Monday, October 8.

   How plants move from internal causes. Movements of vital fluid within walled cells and of diatoms and desmids. How floral clocks and calendars may be made.

6. Monday, October 15.

   How plants move from external causes. The stimuli of light, gravity and other forces that influence plants. The sleep of plants.

7. Monday, October 22.

   How plants increase and multiply. Vegetative and sexual reproduction. How pollen is borne by wind, insects, birds, snails, bats and water. How seeds are scattered to perpetuate the species.

8. Monday, October 29.

   How plants are distributed in relation to their surroundings. The zones of the earth and their vegetation. The part that water plays in determining floras. How plants succeed each other in geologic time.

9. Monday, November 5.

   How plants are distributed in North America. Plants of the coastal plain, sand dune and pine barren. The gulf states, lake shore and stream valley, prairie, forest, grassland and desert. The Pacific Coast.

10. Monday, November 12.

    How plants are distributed in Europe and the Alps. The British Isles, Mediterranean region, Asia, Japan, the Himalayas, Russia and the Atlantic Islands.

11. Monday, November 19.

    How plants are distributed in the tropics of the Old World. The heart of Africa and continental Asia, "the cradle of the human race." Notable plants and delicious fruits of Malaya and the South Sea Islands.

12. Monday, November 26.

    How plants are distributed in the tropics of the New World. Characteristic species of Mexico, Central America, the West Indies, Trinidad and the wilds of South America. The virgin forest of Brazil.

13. Monday, December 3.

    How plants are distributed in South Africa, Australia, New Zealand, Fuegia, and Chile. The region of Cape Horn and Gondwana Land of ancient geologic time.

14. Monday, December 10.

    How Man has influenced the distribution of plants and the course of evolution. His destructive and constructive forces. Brief considerations of plant breeding, natural selection, mutation, heredity and hybridization. Recapitulation.

Field Trip

The class in Botany will be conducted on a field trip under the leadership of Professor Kaiser. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

INORGANIC CHEMISTRY 2

Professor Horn

Descriptive Chemistry

Lectures begin at 7.45 P. M.*

1. Tuesday, September 11.

    Chlorin. Occurrence, preparation, properties. Industrial uses. Isotopy. liquefaction.

2. Tuesday, September 18.

    Chlorin Compounds. Polyvalence of chlorin. Acids of chlorin, and their salts. Modern atomic weight determinations.

3. Tuesday, September 25.

    Bromin, Iodin, Fluorin. Occurrence, preparation, properties. Halogen hydrids and oxids. General chemistry of the halogens. Halogen halids.

4. Tuesday, October 2.

    Physical-Chemical Equilibrium. The law of mass action. The phase rule. Transition points.

5. Tuesday, October 9.

    Sulphur. Occurrence, preparation, properties. Polymorphism. Molecular weight of sulphur. Sulphur chlorids. Sulphur hydrid. Sulphur dioxid.

6. Tuesday, October 16.

    Sulphur Trioxid. Preparation, properties, uses. Principal sulphur acids. Commercial catalysis. Desmotropism. Persulphates. Caro's acid.

7. Tuesday, October 23.

    Selenium, Molybdenum, Vanadium. Photo-chemical effects. Composition of polyacids as exceptions to "Definite Proportions." Discovery of elements consequent upon difficulties in mineral analyses. Vanadium in steels.

8. Tuesday, October 30.

    Nitrogen. Occurrence, preparation, properties. Fixation of nitrogen. Nitrogen hydrids.

9. Tuesday, November 6.

    The Atmosphere. Chemical composition. The noble gases and their uses. Fresh and vitiated air. Air poisons.

*Please note the hour.

10. Tuesday, November 13.
    Oxids of Nitrogen. Nitric, nitrous and hyponitrous acids. Other hydroxids of nitrogen. Nitrogen halids.
11. Tuesday, November 20.
    Phosphorus. Sources, preparation, properties. Allotropism. Phosphorus hydrids, halids, and sulphids. Matches.
12. Tuesday, November 27.
    Oxids of Phosphorus. Phosphoric acid and its salts. Biologic importance of phosphates, and of phosphorus. The meta-phosphoric acids. Hydroxids of phosphorus, and other phosphorus acids.
13. Tuesday, December 4.
    Arsenic and Boron. Sources, preparation, properties. Applications. Oxygen and sulphur acids of arsenic. The boric acids.
14. Tuesday, December 11.
    Scandium, Gallium, Germanium, Indium, Beryllium. Chemical systematics and prophesies based thereupon. Laws of isomorphism, and of specific heat.

ORGANIC CHEMISTRY 2

PROFESSOR GRIFFITH

Carbohydrates, Fats, Oils and Waxes

Lectures begin at 8 P. M.

1. Wednesday, September 12.
   Cellulose—At Home in Plant Structures. Its nature and chemical behavior.
2. Wednesday, September 19.
   Cellulose in Service. Texts and Textiles. Paper, parchment, cotton, linen, ramie, cork, coir, kapok, etc.
3. Wednesday, September 26.
   Chemicalized Cellulose. Demure (rayon, celanese) and devil (guncotton).
4. Wednesday, October 3.
   Starch—From the Storehouses of the Energy-Binders. Its nature, distribution and chemical eccentricities.
5. Wednesday, October 10.
   Starch (Concluded). Physical properties of starch. Its role in plant and animal metabolism.
6. Wednesday, October 17.
   The Sugars. Occurrence in nature. Physical and chemical family traits. The sweet quartette—sucrose, lactose, dextrose and maltose.
7. Wednesday, October 24.
   Oils, Fats and Waxes. Proximate principles. Fixed oils and volatile oils. Oils that will—and oils that will not—saponify. Hydrogenated oils.
8. Wednesday, October 31.
   Oils, Fats and Waxes (Continued). General properties, Origins. Preparation. Uses.
9. Wednesday, November 7.
   The Non-Drying Oils. Cottonseed, olive, almond, peanut, corn, castor, etc.
10. Wednesday, November 14.
    The Drying Oils. Linseed, hemp, poppyseed, soya, tung, fish oils, etc.

11. Wednesday, November 21.
    Fats and Waxes, Vegetable and Animal. Cacao butter, palm oil, lard, tallow and wool fat, beeswax, carnauba wax, etc.
12. Wednesday, November 28.
    Soaps. Saponification, composition and classification of soaps. Soap hokum.
13. Wednesday, December 5.
    Milk and Its Ilk. Butter, cheese, cream, etc. Oleomargarine and butter substitutes. Household tests and legal standards.
14. Wednesday, December 12.
    Milk and Its Ilk (Concluded). Milk and metabolism. Casein and casein products. Billiard balls and bureaus made of milk.

ENGINEERING 4

PROFESSOR WAGNER

Water Supply, Sewers, Canals, Rivers and Harbors

Lectures begin at 8 P. M.

1. Friday, September 7.
    Hydrography. Water surveys of all kinds. Soundings. Current meters. Discharge of streams.
2. Friday, September 14.
    Water Supply. Water and its impurities. Analysis—chemical and biologic. Interpretation of analysis.
3. Friday, September 21.
    Water Supply (Continued). Sources of water. Consumption. Storage reservoirs.
4. Friday, September 28.
    Water Supply (Continued). Construction of reservoirs and dams of earth and masonry. Distributing systems. Aqueducts. Pipes.
5. Friday, October 5.
    Water Supply (Continued). Purification. Distilling. Boiling. Disinfection. Sedimentation. Filtration. Softening. Straining.

No lecture October 12.

6. Friday, October 19.
    Water Supply (Concluded). Rapid and slow sand filters—their design and construction. Reduction of typhoid by filtration.
7. Friday, October 26.
    Sewers. Definitions. Sewerage systems. Requirements of a good system.
8. Friday, November 2.
    Sewers (Continued). Location. Determination of amount of sewage and storm water. Formulae.
9. Friday, November 9.
    Sewers (Continued). Size. Construction. Excavation and refilling.
10. Friday, November 16.
    Sewers (Concluded). Disposition. Processes for purification. Disposal of sludge.
11. Friday, November 23.
    Canals. Classification. History. Cross section. Water supply. Reservoirs. Feeders.

12. Friday, November 30.
    Canals (Concluded). Levels. Locks. Locomotion. Ship canals.
13. Friday, December 7.
    Rivers. Natural features. Protection of banks. Bars. Inundations. Regulation. Slack water navigation.
14. Friday, December 14.
    Harbors. Roadsteads. Harbors, natural and artificial. Dikes. Sea walls. Breakwaters.

ZOOLOGY 3

PROFESSOR SCHMUCKER

Man as the Biologist Sees Him

Lectures begin at 8 P. M.

I—Man's Evolution

1. Monday, January 7.
   Man's Near Kin. Transition forms. Java, Pekin and Piltdown forms. Eoliths, man's oldest implements.
2. Monday, January 14.
   Low Grade Men. The Heidelberg jaw. Neanderthal Man and his wide distribution. The development of stone implements.
3. Monday, January 21.
   The Earliest of Modern Men. "The Old Man of Cro-Magnon." Many kinds of stone and bone implements. The outburst of art.
4. Monday, January 28.
   The First Herders, Planters and Traders. Villages and trade routes. Bronze and iron implements.
5. Monday, February 4
   Present Races of Men. All of one species. The Asiatic Home. Three divisions, based on hair form and skin color.
6. Monday, February 11.
   The People of the United States. Three types of white men. Their European distribution. Their coming to America.

II—Man's Life Story

7. Monday, February 18.
   The Forming of the Body. Egg and sperm. The development in the body. Early nutrition and growth.
8. Monday, February 25.
   Man and Woman. The glands and their hormones. The development of secondary sex characters. The mental factors.
9. Monday, March 4.
   The Prime of Life. Man's adjustment to his environment. Misfits and their treatment.
10. Monday, March 11.
    Why we Die. The increased expectation of life. Its slight effect on extreme age. The accumulation of maladjustments. Science and immortality.

III—Man's Structure

11. Monday, March 18.
    The Machines That Move Us. Bone and cartilage for stiffening. Muscles to produce motion. Nerves to direct it.

12. Monday, March 25.
    Gathering Energy for Living. Food and its potential energy. Converting it into body parts. Using the energy. Throwing off the waste products.

13. Monday, April 1.
    Man's Brain and its Servants. Getting the news from outside. Acting on it. The main office and its branch offices.

14. Monday, April 8.
    What is Disease? Malformations in development. Mechanical injuries and their healing. Invading organisms. Immunity, natural and acquired.

Field Trip

The class in Zoology will be conducted on a field trip under the leadership of Professor Schmucker. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

GEOLOGY 4

PROFESSOR HOWELL

Historical Geology

Lectures begin at 7.45 P. M.*

1. Tuesday, January 8.
    The Great Stone Book. The oldest book in the world, whose earlier chapters were written hundreds of millions of years ago.

2. Tuesday, January 15.
    The Charred First Pages That Have Been Preserved to Us. The difficulty of deciphering the writing on these half-burned leaves.

3. Tuesday, January 22.
    The First Clear Pages of the Record. The chapters which tell of the oldest inhabitants of the earth.

4. Tuesday, January 29.
    The Cambrian Period, Age of Trilobites. The first period of whose life we have a good picture.

5. Tuesday, February 5.
    The Ordovician Period, When the Sea Dwellers Put on Coats of Mail. How the struggle for life made it necessary for many animals to put on armor in order to survive.

No lecture February 12.

6. Tuesday, February 19.
    The Silurian Period, When Life First Invaded the Land. How the long struggle to cross the strand line was at last successful, and the lands of the earth were peopled.

7. Tuesday, February 26.
    The Devonian Period, When Armored Fishes Ruled the Seas, Lakes, and Rivers. How the chordates gained control of the waters of the earth.

8. Tuesday, March 5.
    The Carboniferous Period, the Age of the Great Coal Forests. How the fishes grew legs and became amphibians.

9. Tuesday, March 12.
    The Permian Period, When the Conditions of Life were Difficult, and Only the Hardy Survived. How the great cold and widespread aridity of that time caused the extinction of many forms of life.

* Please note the hour.

10. Tuesday, March 19.
    The Triassic Period, When Life Grew Easier, and the Reptiles Rose to Power. How this first period of the Mesozoic Era ushered in a new assemblage of animals and plants.
11. Tuesday, March 26.
    The Jurassic Period, Age of the Mighty Dinosaurs. The heyday of reptiles, and the first reptilian birds.
12. Tuesday, April 2.
    The Cretaceous Period, End of the Reign of the Reptiles. When pterodactyls flitted among the branches of the first deciduous trees.
13. Tuesday, April 9.
    The Tertiary, Age of the Animals with Hair. How the mammals replaced the reptiles as the dominant forms of life.
14. Tuesday, April 16.
    The Quaternary, Age of Man. Human races which fell by the wayside, and why ours still survives today.

Field Trip

The class in Geology will be conducted on a field trip under the leadership of Professor Howell. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

PHYSICS 1

PROFESSOR SEELY

Matter, Measurement, and Mechanics

Lectures begin at 8 P. M.

1. Wednesday, January 2.
   Man's curiosity about material objects builds a science. Properties of matter. Measurement. States of matter.
2. Wednesday, January 9.
   Motion everywhere. How objects without power to move themselves are made to move. How men study, classify and measure motion.
3. Wednesday, January 16.
   A great man thinks about motion. Newton's Laws. Momentum, acceleration, inertia.
4. Wednesday, January 23.
   Many bodies have two or more motions at the same time. Complicated motions may be made simple for study. Whirling motions.
5. Wednesday, January 30.
   How work gets done and is measured. Energy never created or destroyed.
6. Wednesday, February 6.
   A great man thinks about falling objects. Newton's Law of Gravitation. Weight, equilibrium and stability.
7. Wednesday, February 13.
   How the motion of falling bodies is measured. Paths of projectiles. The pendulum.
8. Wednesday, February 20.
   Man's intelligence leads him to use tools and machinery. Six simple machines.
9. Wednesday, February 27.
   Machinery limited in its uses. Friction, tension, and thrusts.

10. Wednesday, March 6.
    How liquids may multiply forces without changing the amount of energy and work. Liquid pressure. The hydrostatic paradox.
11. Wednesday, March 13.
    Why some bodies float in water. Densities and specific gravity.
12. Wednesday, March 20.
    How liquids climb in tubes. Surface tensions, films and capillarity.
13. Wednesday, March 27.
    The turbulent ocean in which we live. Atmospheric pressure, barometers, weather maps. Compressibility of gases.
14. Wednesday, April 3.
    How gas properties are measured. Three gas laws. Atmospheric density and buoyancy.

MUSEUM TALKS

Monday evenings at 7 o'clock

This series comprises informal talks, given on Monday evenings, illustrated by specimens in the Museum.

PROFESSOR HOWELL

Minerals, Rocks, and Fossils

Sept. 17. Minerals, the Components of all Rocks.
Sept. 24. Sediments which form the Bedded Rocks.
Oct. 1. Rocks which Cooled from a Molten Condition or have been Altered by Pressure and Heat.
Oct. 8. Fossil Plants, and how they are Formed.
Oct. 15. Invertebrate Fossils, their Abundance and Practical Uses.
Oct. 22. Fossil Vertebrates, and the Story of Life they Unfold.

MISS BORDEN

Animals of the Water

Oct. 29. The "Fixed" or Non-Moving Water Animals.
Nov. 5. The Slow-Moving Water Animals.
Nov. 12. The Swifter-Moving Water Animals.
Nov. 19. Water Animals with a Crustlike Covering.
Nov. 26. Water Animals with a Shell Covering.
Dec. 3. The Higher and More Intelligent Water Animals.

MR. LAWRENCE

Animals of the Land

Dec. 10. Animals That Dig into the Ground.
Dec. 17. Animals of the Deserts.
Dec. 24. No lecture.
Dec. 31. No lecture.
Jan. 7. Animals of the Mountains.
Jan. 14. Animals That Live in Forests.
Jan. 21. Animals That Live in Trees.
Jan. 28. Animals That Live in Open Fields.

PROFESSOR SCHMUCKER

Animals of the Air

Feb. 4. Insects and their flight.
Feb. 11. "Fliers" that only soar.
Feb. 18. Feathers as a means of flight.
Feb. 25. Birds of strong flight.
Mar. 4. The story of bird migration.
Mar. 11. Nature's furry flier.

PROFESSOR KAISER

Great Groups of Plants

Mar. 18. Slime Moulds: Their plasmodial and sporangial stages. Spore-cases of great delicacy and beauty.
Mar. 25. Blue-Green Algae: Early organisms of the cooling earth-crust. Spherical and filamentous forms.
Apr. 1. Green Algae and Algal Fungi: Desmids and diatoms. Bread mould. Beauty in minute plant life.

Apr. 8. Brown and Red Algae and Sac Fungi: Huge seaweeds, exquisitely divided tiny ones and the tempting truffle.

Apr. 15. Lichens: That curious class of dual organisms which offers revelations of interest in almost endless forms.

Apr. 22. Mushrooms and Their Kin: Food and poison for mankind, exhibiting a riot of form and color in the fascinating realm of saprophyte and parasite.

GENERAL SCHEDULE OF REGULAR LECTURES

Subjects of courses in each of the four successive years constituting a full term.

ENGINEERING

1. Materials of Engineering Construction.
2. Civil Engineering Structures.
3. Roads, Railroads and Tunnels.
4. Water Supply, Sewers, Canals, Rivers and Harbors.

PHYSICS

1. Properties of Matter. Mechanics.
2. Heat and Sound.
3. Light.
4. Electricity and Magnetism.

INORGANIC CHEMISTRY

1. General Principles, Notation, Nomenclature.
2. Descriptive Chemistry.
3. Descriptive Chemistry.
4. Descriptive Chemistry.

ORGANIC CHEMISTRY

1. General Principles, Aliphatic Hydrocarbons.
2. Carbohydrates, Fats, Oils and Waxes.
3. Cyclic Hydrocarbons.
4. Compounds of Nitrogen.

ZOOLOGY

1. Invertebrate Animals.
2. Vertebrate Animals.
3. Human Biology.
4. Principles of Animal Life.

BOTANY

1. Morphology.
2. Taxonomy.
3. Taxonomy (continued).
4. Physiology and Ecology.

GEOLOGY AND PALEONTOLOGY

1. Physical Geography.
2. Physical Geology.
3. Paleontology.
4. Historical Geology.

LECTURES UNDER RICHARD B. WESTBROOK FOUNDATION

1912.—Ancient Civilization of Babylonia and Assyria. *Morris Jastrow, Jr., Ph.D.*
1913.—Conservation of Natural Resources. *Gifford Pinchot, Marshall O. Leighton, Overton W. Price, Joseph A. Holmes.*
1914.—The Theory of Evolution. *William Berryman Scott, Ph.D., LL.D.*
1915.—Invisible Light. *Robert Williams Wood, LL.D.*
1916.—Aspects of Modern Astronomy. *John Anthony Miller, A.B., A.M., Ph.D.*
1917.—Heredity and Evolution in the Simplest Organisms. *H. S. Jennings, B.S., A.M., Ph.D., LL.D.*
1918.—The Chemistry, Nutritive Value and Economy of Foods. *Harvey W. Wiley, A.M., M.D., B.S., Ph.D., LL.D., D.Sc.*
1919.—The Origin and Antiquity of the American Indian. *Aleš Hrdlička, M.D., Sc.D.*
1920.—Chemistry and Civilization. *Allerton S. Cushman, B.S., A.M., Ph.D.*
1921.—Microbiology. *Joseph McFarland, M.D., Sc.D.*
1922.—Evolution of the Human Face. *William K. Gregory, Ph.D.*
1923.—The Philosophy of Sanitation. *George C. Whipple, B.S.*
1924.—The Distribution of American Indian Traits. *Clark Wissler, A.M., Ph.D.*
1925.—Structural Colors. *Wilder D. Bancroft, Ph.D., Sc.D.*
1926.—The Animal Mind; its sources and evolution. *George Howard Parker, Sc.D.*
1927.—An Interpretation of Atlantic Coast Scenery. *Douglas W. Johnson, Ph.D.*
1928.—The Science of Musical Sounds. *Dayton C. Miller, Ph.D.*
1929.—Volcanoes and Vulcanism. *William B. Scott, Ph.D., LL.D.*
1930.—Present Problems of Evolution. *Edwin Grant Conklin, Ph.D., ScD., LL.D.*
1931.—The Problems of the Origin and Antiquity of the American Aborigines in the Light of Recent Explorations. *Aleš Hrdlička, M.D., Sc.D.*
1932.—Common Sense, Science and Philosophy. *John Dewey, Ph.D., LL.D.*
1933.—Social Relations in Monkey, Ape and Man. *Robert M. Yerkes, A.M., Ph.D., Sc.D.*
1934.—Chemistry and Industrial Progress as exemplified in the Study of Hydrogen and Oxygen. *Hugh S. Taylor, D.Sc., F.R.S.*

WESTBROOK FREE LECTURESHIP PUBLICATIONS

Can be purchased through any book-store

Ancient Civilization of Babylonia and Assyria, by *Morris Jastrow, Jr.* J. B. Lippincott Co.

The Theory of Evolution, by *William Berryman Scott.* The Macmillan Co.

Life and Death, Heredity and Evolution in Unicellular Organisms, by *H. S. Jennings.* Richard G. Badger.

Chemistry and Civilization, by *Allerton S. Cushman.* Richard G. Badger.

Fighting Foes too Small to See, by *Joseph McFarland.* F. A. Davis Co.

The Relation of Nature to Man in Aboriginal America, by *Clark Wissler.* Oxford University Press.

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Vol. 2.—Report on Fresh-water Sponges Collected in Florida. *Edward Potts.*
Notice of Some Fossil Human Bones. *Joseph Leidy.*
Description of Mammalian Remains from Rock Crevice in Florida. *Joseph Leidy.*
Description of Vertebrate Remains from Peace Creek, Florida. *Joseph Leidy.*
Notice of Some Mammalian Remains from Salt Mine of Petite Anse, Louisiana. *Joseph Leidy.*
On Platygonus, an Extinct Genus Allied to the Peccaries. *Joseph Leidy.*
Remarks on the Nature of Organic Species. *Joseph Leidy.* $1.00

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BULLETIN

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Republication of Conrad's Fossils of the Medial Tertiary of the United States. Introduction by *William H. Dall.* (Out of Print.)

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SYDNEY L. WRIGHT, *Editor*

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ADAPTIVE COLORATION IN A FRESHWATER GASTROPOD[1]

By Edward M. Kindle

Introduction

Pleurocera acutum Rafinesque is limited in its distribution, both as a fossil and as a living species, to the Great Lakes, their connecting rivers and the St. Lawrence River. As a fossil it appears to be known only in the Quaternary gravel bars of the old channels of Niagara River near Goat Island.[2] It has been reported also in the Pleistocene gravels at Queen Victoria Park, Niagara Falls.[3] The living shell thrives best near exposed points subject to strong wave action.

The occurrence here recognized for *P. acutum* is based on the synonymy approved by F. C. Baker.[4] The distribution of this species as reported by Baker[5] and indicated by other records[6] gives it an occurrence extending from Lake Superior to Montreal. The distribution of this Great Lakes species is remarkable for the wide gaps between the localities where it has been found.

Goodrich[7] says that "Apparently the mollusk is entirely absent from Lake Michigan and from the exposed parts of Lake Huron and Lake St. Clair. It lives in the St. Clair River, Detroit River and in great numbers in Lake Erie." Forms of *Pleurocera* closely related to *P. acuta*, which occur in various rivers of the Great Lakes drainage, Baker has placed in the variety *Pleurocera acuta tracta* Anthony.

It is the purpose of this paper to describe an example of adaptive coloration in *P. acutum* at Point Pelee, Lake Erie, which came to my notice while studying the history and development of the Point Pelee foreland.

It is quite possible for a naturalist to be on the ground where the development of a new variety or species is in progress and not realize what is taking place. That has been my own experience with the gastropod *Pleurocera acutum* Raf. which is the dominant mollusc on both sides of Point Pelee, a sand spit which stretches nine miles into Lake Erie from the Canadian shore.[8] I collected this shell from both the east and west side of this spit in 1931 but

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[1] Published with the permission of the Director, Geological Survey of Canada, Department of Mines, Ottawa.

[2] Grabau, A. W.: Guide to Geol. & Pal. Niagara Falls & Vicinity, N. Y. State Mus. Bull., Vol. 45, p. 238, 1901.
Kindle, E. M., & Taylor, F. B.: Niagara Folio, U.S.G.S., No. 190, p. 105, 1914.

[3] Coleman, A. P.: Twelfth International Geol. Cong. Guide Book 4, p. 42, 1913.

[4] Baker, F. C.: The Freshwater Mollusca of Wisconsin, Wisc. Geol. Surv. Bull. 70, p. 171, 1928.

[5] *Ibid.*, pp. 171–173.

[6] Canadian Records assembled by A. LaRocque for *Pleurocera acutum* Rafinesque are: As *Pleurocera subulare* (Lea)—St. Joseph's Is., L. Huron, Richards, H. G.: Mollusks from St. Joseph's Island, Ont., Can. Field Naturalist 46:33, Feb. 1932. As *P. acuta* Raf.—Lake Erie, Ahlstrom, E. H.: Mollusks collected in Bass Is. region L. Erie, Nautilus 44:44, Oct. 1930. As *Melania subularis* Lea—St. Lawrence at Montreal. Whiteaves, J. F.: On the Land and Freshwater Mollusca of Lower Canada. Can. Nat. 1863, pp. 50–65 & 98–107. As *P. sublare* —Lake Ontario stations 4, 5; 1–5 feet. Kindle, E. M.: The Bottom Deposits of L. Ontario. Trans. Roy. Soc. Can., 3rd Ser., Vol. XIX, pp. 67, 1925.

[7] Goodrich, Calvin: The Mollusca of Michigan University Museums, Univ. of Michigan Handbook series no. 5, p. 82, 1932.

[8] Kindle, E. M.: Erosion and Sedimentation at Point Pelee, 42nd Ann. Report, Ont. Dept. Mines, vol. 42, Pt. II, 1933, Fig. 1, Fig. opp. p. 2 and Map No. 42A.

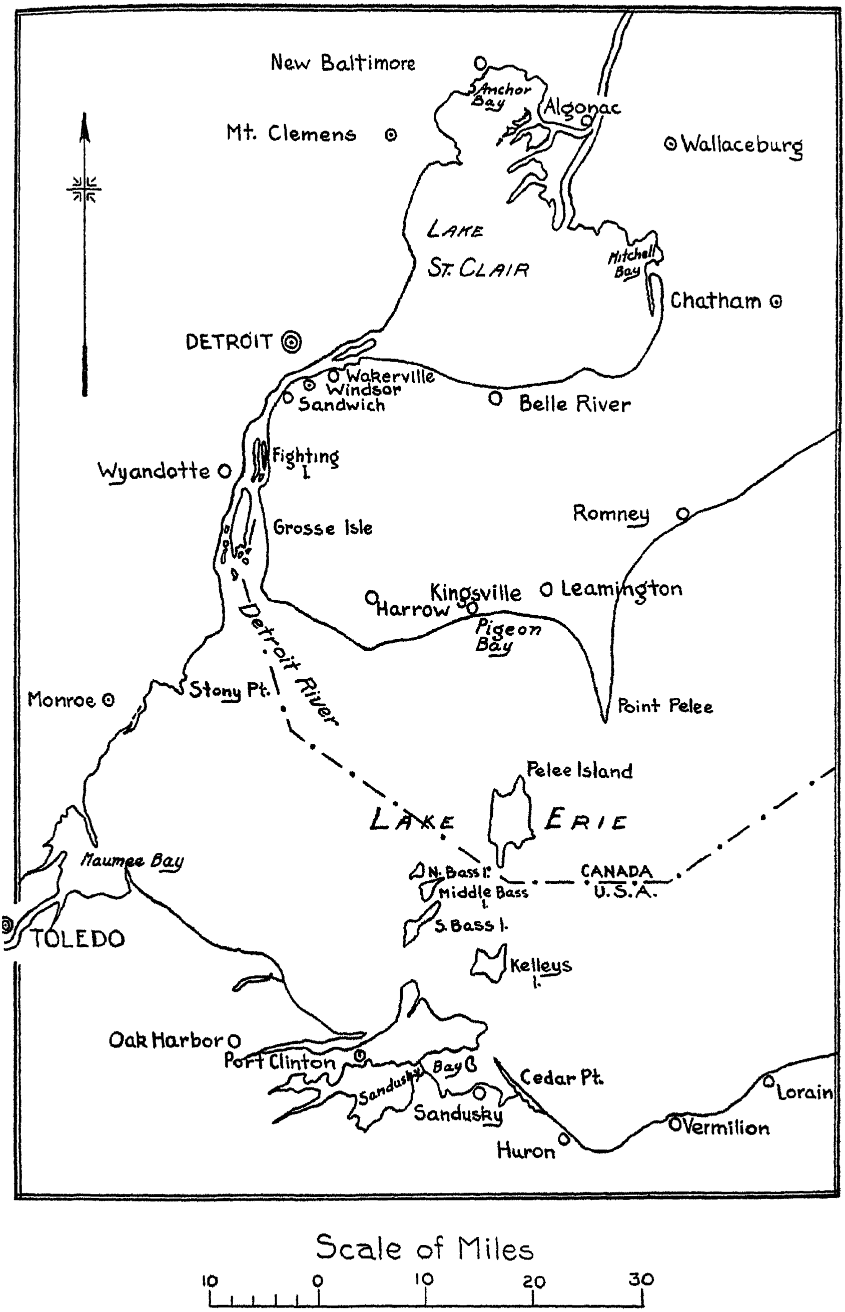

FIG. 1.—Key map showing the location of Point Pelee in the western part of Lake Erie.

did not note in the field that the shells from the two sides differed from each other. Examination in the laboratory showed that a large percentage of the shells from the east side are dark or nearly black while those from the west shore are with few exceptions light colored. The results of office examination led me to make much larger collections from both localities in 1933 which fully confirmed the evidence of the earlier collections that a dark colored race of this species occupies the east shore and a light colored race the west shore. (See Fig. 2.)

CURRENTS

In conjunction with contrasted conditions on the two sides of Point Pelee, currents,—one of the agencies responsible for the formation of the foreland,—cause it to act as a barrier between shells living on the east and west sides. (See Fig. 1.) Southward-moving currents near the tip of Point Pelee are generally present even in quiet weather. Sometimes these currents set southwards with considerable velocity. The dangerous character of the currents which near the tip of the Point move toward the middle of Lake Erie has led the park authorities to post notices warning bathers against bathing near the southern tip of the spit. Various observations have been made on the rate of this current, using submerged canvas-covered frames attached to a float with a small flag. The rate of movement over a measured distance was timed. One observation on the west side, made when the lake was perfectly quiet except for a long swell, showed in water 50 feet from shore and about 8 feet deep a southward current of 1.79 miles per hour. As a result of the southward moving currents on opposite sides of the tip of Point Pelee there is likely to be very little opportunity for living shells from either of the two assemblages to pass round the point and up the opposite shore more than a few hundred yards. The prevailing southward currents thus function as a barrier in preventing the free mingling of individuals from the east and west side habitats. Nearly all of those which might succeed in rounding the Point in calm weather would be likely to be carried toward the mid-lake region in succeeding spells of heavy weather.

This nine mile long spit, as a result of the southerly currents, acts as a barrier between two contrasted lake shell habitats on opposite sides of it. Here are conditions which tend to preserve peculiarities impressed by a special local environment, and protect them from the dissipation which results from free migration. As Jordan has said: "Localization holds peculiarities true; migration lets them slip. Local peculiarities disappear by wide association and are intensified when individuals of similar peculiarities are kept together."[1]

The differences which have arisen between the east and the west shore representatives of *P. acutum* are chiefly confined to color and size.

CONTRASTS IN COLOR AND SIZE

The 1933 collection from the west side of the spit, which was obtained on the beach about three miles above the tip of the Point, contains 272 shells. Of these, 91% are light colored shells and only 5% dark. (See Fig. 2.) The remainder of these shells includes a few with the apical half of the shell dark colored and lower whorls light colored; there are also a few shells with different shades of brown color.

The east shore collection of 587 shells made opposite the end of an east-west park road about 2½ miles north of the tip shows only 36% of light colored shells and 54% of dark shells with 10% of shells of mixed colors, including cinnamon brown and shades of grey which do not fall definitely into either of the other two classes.

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[1] Jordan, D. S.: Evolution and Distribution of Animals. Popular Science Monthly, vol. 37, p. 318.

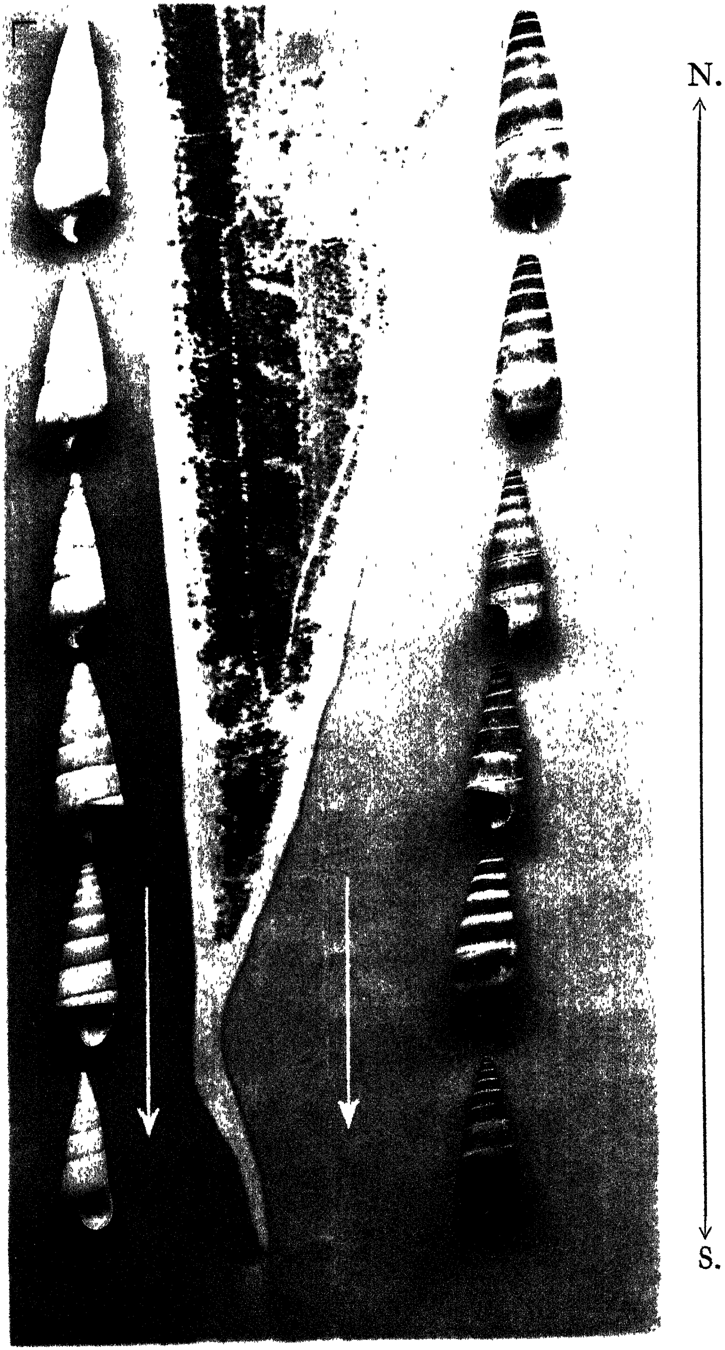

Fig. 2

The color of the shells which are here called dark, when compared with Ridgeway's color plates, lies between his "heliotrope slate" and "dull purplish black."[1] The rather rare brownish shells fall near "sorghum brown" and "pinkish buff."[2]

The smaller collections made in 1931 show about the same ratio of light and dark shells, the dark shells being rather scarce on the west side and the light ones abundant; while on the east shore dark colored shells decidedly outnumber light ones.

The somewhat larger size of the east shore as compared with the west shore shells appears evident from a casual examination of fair sized collections from the two sides. Comparative figures indicating the contrast in size shown by the east and west shore shells were obtained by selecting from the light colored shells of the two shores the ten largest specimens. Only one of the east shore shells has a length of 25 mm. while the other nine range between 18 and 23 mm. in length. The east shore shells show an average maximum of width of 7.7 mm., while the average width for the west shore shells is 9.3 mm.[3]

The larger sized shell found on the east shore indicates that *P. acutum* finds there a closer approach to the optimum conditions of growth than on the west shore. The contrasted bathymetric conditions east and west of Point Pelee seem to offer a clue to the reason for the location of optimum growth conditions on the east side. Lake Erie west of Pt. Pelee, Pelee Island and Sandusky Bay is a shallow basin with an area of more than a thousand square miles which is nowhere more than six fathoms deep. On the east side of Pt. Pelee the six fathom contour lies within six miles while depths exceeding 100 feet appear to the southeast. This relationship of the deep eastern and the shallow western basins of the lake should result in the upwelling of colder water on the east shore of the Point than on the west shore during the prevalence of northerly winds. The somewhat lower temperatures which must at times characterize the water on the east side of Point Pelee during the hot season may be a factor in producing the larger and more robust shell of the east side habitat. In this connection Whitfield's[4] experiments in raising four generations of *Limnaea megasoma* in an aquarium are interesting. The third generation had diminished in size to a shell four-sevenths the length of the great grandparents which an experienced conchologist stated could have no specific relation to the ancestral shells. Shells of this species introduced into a pond near Albany, N. Y., when the aquarium experiments began thrived and produced shells of the usual type and size. In this case reduced size, slender shells and other changes came about under mild and equable indoor conditions while the species bred true to type under the wide range of outdoor temperature which is characteristic of the Albany climate.

P. acutum probably originated in the large river which in the interval immediately preceding the Glacial period traversed the depression now occupied by Lake Erie. Its occurrence in Quaternary gravels at Niagara Falls which are associated with an early stage of the Niagara River suggests that it has been long adapted to a cold water habitat and that it would probably find in L. Erie optimum habitat conditions in such a locality as the east shore of Pt. Pelee and less favorable ones along the shores of the shallow part of the Lake west of Point Pelee.

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[1] Ridgeway, Robert: Color standard and Color Nomenclature, pl. 50.

[2] *Ibid.*, plates 29 and 39.

[3] Note: These figures represent dead shells all of which have the apex of the spire and margin of the outer lip broken off by wave action so that the figures are slightly smaller than if taken from living shells.

[4] Whitfield, R. P.: Description of *Lymnaea* (*Bulimnaea*) *megasoma* Say with an account of changes produced in the offspring by unfavorable conditions of life. Bull. Amer. Mus. Nat. Hist. I, p. 29, 1882.

CONTRASTED FEATURES OF HABITATS

In seeking an explanation of the different types of shell which prevail on the opposite sides of Pt. Pelee there appear to be only two features of the lake which invite consideration. As already stated, one of these is the contrast in depth of water east and west of the foreland; the other is the character of the bottom.

In contrast with the west shore, where the beach west of the big marsh is growing, the east shore for a long period has been eroding. Taverner and Swales[1] described the conditions there—previous to my first visit—as follows:

> "In fact there is every evidence that this shore is being eroded. . . . The older residents say that some forty years ago it was nearly three quarters of a mile wide and clothed with heavy hardwood timber. Even since our first visit in May, 1905, we can see that the Point has lost considerable land along the shore, nor have we observed that there has been any compensating accumulations made at other points on this side. The fishermen tell us that the bottom off shore is composed of mud, and filled with roots and prostrate tree trunks. On the beach every here and there are often found large regular masses of peat that seem to have been torn up from the bottom and washed ashore."

On both shores the beaches are composed almost entirely of sand and gravel but along the east shore numerous blocks of peat may sometimes be seen at points where during years of high lake level erosion is in progress. Considerable patches of bottom within the ten foot contour are doubtless free of sand and furnish with the loose blocks a firm bottom, black in color, on which the bulk of this species probably lives. The black peat and forest débris appear to be the chief bottom features in which the east and west shores differ, both being entirely absent from the west shore bottom and present on parts of the east shore bottom. After heavy storms pieces of peat of various sizes up to 2 by 4 feet have been found on the beach of the east shore, having been separated from the lake bottom by wave action. The peat bed from which they come is now covered by the lake and represents a former eastward extension of the marsh, the protecting sand bar having moved westward to its present position. The dark color of the majority of the east shore shells is probably referable mainly to the local peat facies of the forest bordered east side. Another element which may have contributed to the differentiation of the dark colored east shore variety is the heavy forest near the shore. On the west side of Point Pelee a gravel or sand beach, 200 or 250 feet wide, rising from the water's edge, generally lies between the lake and the forested zone of oak and cedar. This wide belt of sand and gravel is without vegetation, except for occasional patches of shrubs near the forest border which is too far from the lake in most places to shade the water. It gives the impression of a growing shore line.[2] It is only near the tip of the forested part of the point that the contrasts between the east and west sides is not very pronounced. The extension of forest to the shoreline on the east side and consequent shade there on the lake margin during the last quarter of the day may be a minor factor in producing a darker shell on the east than on the west shore. A wide beach on the west side eliminates shade from the lake environment where a light color would help to conceal the shell on the sand bottom just as a dark color on the east side among the blocks of peat would offer protection.

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[1] Taverner, P. A., and Swales, B. H.: The Birds of Point Pelee: The Wilson Bull. Quart. Jour. of Ornithology, vol. 19, p. 41, 1907.

[2] At Presque Isle Park foreland, Erie, Pa., growth is toward the east. Mr. W. L. Morrison, Supt. State Park & Harbor Commission of Erie, Pa., says: "In the past we are satisfied that Presque Isle Peninsula has drifted east at the rate of over one half mile in a hundred years." (Letter to W. R. Rogers, July 26, 1933.)

Specimens from the south shore of Lake Erie at Sandusky Bay and three other localities, labelled *P. subulare* Lea, were kindly loaned me by Paul Bartsch of the U. S. National Museum for comparison with the Point Pelee representatives of *P. acutum*. The south shore specimens show considerable variation in surface markings. All of the specimens except one from station 218218 show prominent revolving lines in the middle of the upper whorls; only one of the specimens from station 218219 shows these revolving lines distinctly. In the material from another station the revolving line in middle or upper whorls and the revolving lines on the lower half of the last whorl are missing in all the specimens. Although these south shore specimens from different localities display marked contrasts in the development of surface ornamentation sharp contrasts in color are absent.

Adaptive coloration in gastropods may occur in small as well as in large lakes. E. J. Whittaker has recorded his observations on color contrasts in two gastropods which live in a very small lake near Ottawa, Canada, only a few hundred yards in diameter. On one side of this lake *Valvata tricarinata* and *Amnicola porata* occupy a habitat at the foot of rock cliffs in which plants are few and where these two gastropods "had by living on the dark clay and on rock fragments incorporated the colors of these materials into their shells." In a pond lily habitat on the opposite side of the lake these two shells have in place of the black color of the stony habitat, a "delicate or pronounced shade of green" which Whittaker states "extends deep into the shell."[1]

SIGNIFICANCE OF COLOR

Gastropods display an interesting variety of ways and means of escaping their natural enemies. Some resort to camouflage, like the genus *Xenophora* which seeks to avoid observation by gluing shells, stones and various kinds of débris to the upper portion of its whorls. Long and pointed shells which it sometimes attaches to its own shell give it, for predatory fishes, the formidable appearance of the spiny Murex and thus contribute to its protection. Others like the Cones have the protection of a poison gland and dangerous teeth. The brilliant colors of the Cones and certain species of *Strombus* which mimic them probably serve as warning colors to potential enemies.[2] The great majority of shells however appear to achieve some degree of protection by means of gradually acquired colors which help to conceal them.

The predatory squids use adaptive concealing colors with the object of making themselves invisible or inconspicuous to their prey. Just as an Esquimau when sealing among ice cakes places a rectangular piece of white canvas across the bow of his Kyak to make it resemble an ice cake, a squid changes the color of its skin to match its environment. Verrill[3] has described the color technique which aids the squid in catching fish:

> "Sometimes after making several unsuccessful attempts, one of the squids would suddenly drop to the bottom, and resting upon the sand, would change its color to that of the sand so perfectly as to be almost invisible. In this way it would wait until the fishes came back, and when they were swimming close to or over the ambuscade, the squid,

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[1] Whittaker, E. J.: Bottom deposits of McKay Lake, Ottawa; Trans. Roy. Soc. of Canada, Sect. IV, vol. 16, p. 155, 1922.

[2] Cooke, H. A.: Molluscs and Brachiopods, Macmillan & Co., London & N. Y., pp. 64–69, 1895.

[3] Verrill, A. E.: The Giant Cuttle-Fishes of New Foundland and the Common Squids of the New England Coast. Amer. Naturalist, Vol. VIII, March, 1874, pp. 172–173.

> by a sudden dart, would be pretty sure to secure a fish. Ordinarily, when swimming, they were thickly spotted with red and brown but when darting among the mackerel they appeared translucent and pale."

None of the gastropods have developed the principle of protective coloration to the perfection which it has reached in the Octopus.[1] But conchologists have cited numerous examples of the influence of the bottom on the color of sea shells. Gould,[2] speaking of the shells found in the sandy harbor of Provincetown, Mass., says: "The color of all the shells in that harbor is remarkably light."

Prof. E. S. Morse[3] in speaking of adaptive coloration in freshwater molluscs says: "The freshwater snails have similar shades to match their peculiar habitats. The freshwater mussels, colored likewise, brown, greenish or black, accord with their places of refuge."

Prof. E. S. Morse in commenting on Darwin's failure to recognize protective coloration in mollusca pointed out various examples of such coloration to be seen in the molluscs of New England.[4] Among those cited are the following:

> "In pools left at low tide where the rocks are often clothed with red calcareous algae we find the little red Chiton. . . . *Margarita helicina* I have found in numbers on the large Laminarian and on sea weed at low water mark, and its color is decidedly protective; while other species of *Margarita* dredged in deep water or shelly ground are whitish, pearly or red.
>
> The protective coloring of certain species is well seen upon stones dredged in deep water, the various molluscs adhering to them closely resembling the calcareous algae and the stones themselves."

The Rev. S. S. Pearce has described a variety of land snail, *Helix caperata* var. *ornata*, which is distinguished by dark bands on a white ground. This variety he found confined almost entirely to downs where sheep were accustomed to pasture associated with the common or mottled form, while the latter form alone occurred in localities where sheep were not accustomed to feed. Assuming then, as is probably the case, that sheep, in the course of their close pasturing, devour many small snails, he believes that individuals of the more conspicuous form *ornata* were more likely to be noticed, and therefore avoided, by the sheep than the mottled form, which would more easily escape their observation. Hence the var. *ornata* is due to the advantage which strikingly colored individuals obtained owing to their conspicuous habit, as compared with the typical form, which would be less readily detected.[5] This appears to be an example of a variety based on the development of warning colors within a short period.

Cooke[6] has illustrated some strikingly unlike varieties of the marine gastropod *Purpura lapillus* L.,[7] representing fifteen different types of the

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[1] Mr. J. Hornell has observed an Octopus suddenly change the color of the whole right or left side of its body and of the arms on the same side to a snowy whiteness. Such color changes are automatically made according to the material on which they crawl. Hornell, J.: Jour. Mar. Zool., vol. I pp. 3, 9.

[2] Gould, A. A.: Invertebrate animals of Mass., 1841, p. 78.

[3] Morse, E. S.: Adaptive coloration of Mollusca, Proc. Boston Soc. Nat. Hist., vol. 14, April, 1871, p. 143.

[4] Morse, E. S.: *Ibid.*, p. 144.

[5] Cooke, A. H.: Molluscs and Brachiopods, p. 89, 1895.

[6] Cooke, A. H.: Molluscs and Brachiopods, p. 91, fig. 35, 1895.

[7] *Note:* An exhibit prepared by A. H. Cooke showing eight well-marked varieties of this shell which are associated with particular types of environment on the coast of Great Britain may be seen in the Brooklyn, N. Y., Museum.

British coast shell with respect to kind of rocks or bottom, exposure to waves and food supply. A variety with very striking banding in rings of black and white is from a station where its bands blend well with the rock which is veined and colored.[1]

The surprising results obtained by Hazay with *Limnaea peregra* and *L. ovata* indicate the response which some gastropods make to changed environments. He succeeded in rearing specimens of so-called *Limnaea peregra* from the ova of *L. ovata* and the so-called *L. ovata* from the ova of *peregra*, simply by placing one species in running water, and the other in still water.[2]

Professor Baker's investigation of the sources of fish food in Oneida Lake, New York, disclosed the fact that the fresh water molluscs supply 24 per cent. of the food of many fishes,[3] in addition to serving as food for leeches, frogs, salamanders, newts, turtles and various insects. Baker finds that 46 of the 225 species of Illinois and New York fresh water fishes, or about one fifth, eat shell fish. Some of these fishes possess crushing apparatus especially adapted to a shell fish diet. In the case of several species the percentage of shell fish food is very high, the Sheepshead consuming 100 per cent.; Lake Sturgeon and Spotted Sucker upwards of 90 per cent.[4]

It appears obvious that a bottom dwelling snail like *P. acuta*, with a hoard of keen eyed shell eating fish and other enemies constantly looking for it, would find a color which blends well with the bottom material on which it lives a substantial protection against the ever present danger of becoming fish food. The logical conclusion appears to be that the light horn colored race which greatly predominates on the light colored sandy bottom west of Point Pelee and the dark slate colored variety which dominates the section of the peat strewn bottom on the east side have arisen through the greater average destruction by predatory animals of shells which did not possess protective colors suitable to these contrasted types of habitat.

TIME FACTOR

If the dark variety of *P. acutum* is a by-product of the remnants of an old peat bed on the lake bottom east of Point Pelee, as I have endeavored to show, its development belongs to a late stage in the history of Lake Erie. The Point Pelee foreland came into existence after the Lake had dropped from its early high level stage represented by the Lake Whittlesay beach. After L. Erie had dropped to its present level the Pt. Pelee foreland was formed and had for a considerable period a southeasterly trend. During this stage a marsh developed within the protecting V-shaped sand bars. Later the marsh and the enclosing bars migrated westward,[5] leaving a part of the peat bed formed during the time the foreland had a southeasterly trend on the lake bottom exposed to wave erosion. The development of the dark colored variety of *P. acutum* would thus correlate with the period during which the westward migration of Pt. Pelee has been in progress. No definite estimate of the time during which the Point has been migrating westward can be made but it probably does not exceed a few hundred years.

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[1] Cooke, A. H.: Molluscs and Brachiopods, pp. 69–70, fig. 35.

[2] Cooke, A. H.: *Ibid.*, p. 93, 1895.

[3] Baker, F. C.: The relation of shell fish to fish in Oneida Lake, N. Y. N. Y. State College of Forestry, vol. 17, No. 27, Circular 21, pp. 18–22, 1918.

[4] *Ibid.*, p. 19.

[5] Kindle, E. M.: Erosion and sedimentation at Point Pelee; Ont. Dept. of Mines, 42nd Ann. Rept., vol. XLII, Pt. II, 1933, p. 11.

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A RATIONAL LACTOMETER

BY DAVID WILBUR HORN, PH.D.

When, in the business evolution incident to the World War, standardization of laboratory apparatus was undertaken, it became evident that in the domestic trade there was no such thing as a rational lactometer.[1] By a rational lactometer is here meant an ideal lactometer resulting from a studied effort to state specifications that adapt older ideas to modern usage. Such specifications should be general so that by them large or small instruments equally well adapted to modern usage may be made at will.

The characteristic of routine milk analysis today is that it rests upon the joint use of the lactometer reading and the butter-fat percentage. Had the means for reading both of these values been developed *pari passu* to present-day status, then no adaptation of one to the other might be needed. But the lactometer developed into forms closely like those of today many years before a dependable and sufficiently quick method for butter fat was invented. Since the Babcock centrifugal method was devised, some new domestic lactometers have been described, including Dr. Babcock's lactometer,[2] the so-called U. S. Department of Agriculture lactometer of Shaw & Eckles,[3] and the State lactometer of California of Dr. Stone.[4] None of these meet the requirements of a rational lactometer as defined above, and they differ from each other in such ways that they must be marketed as three distinct instruments. At least two other types of lactometer persist from earlier days—the Quevenne and the New York Board of Health lactometers. These five instruments, perhaps along with some less known ones, leave the dealer and the purchaser at some loss when trying to decide upon the best.

The implicit confusion, ingrained in lactometry, is certified by the disagreement among American lexicographers[5] upon the definition of the word, *lactometer*. The dilemma is perhaps to be traced to Dr. Chandler, who became the best known pioneer in milk control work for health boards in the

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[1] Apparently the total volume of business involved in the production and sale of lactometers is too small to warrant much attention from the glass blower or excite much interest among the dealers in laboratory supplies.

[2] Wisconsin Agr. Exp. Station, 8th Annual Report, 1891. p. 302.

[3] U. S. Dept. Agr., Bureau of Animal Industry Bulletin 134. 1911.

[4] Amer. J. Pub. Health, XXIII, 1933. p. 939.

[5] Cf. Funk & Wagnall Standard Dictionary; G. & C. Merriam Co., Webster's International Dictionary.

United States. Chandler[6] applied the name *lactometer* to the same instrument that Quevenne[7] thirty years before had christened a *creamometer*, a device for estimating butter fat. Chandler's other instrument, known today in America generally as the *New York Board of Health lactometer*,[8] he referred to as "the *galactometer* of Dinocourt, in use in Europe."[6] The instrument now marketed under the name *Quevenne lactometer* is the vestigial remainder of a scientific instrument Quevenne invented and for which he coined the name *lactodensimeter*.[9] The first lactometer of record that I have been able thus far to locate is the lactometer of Dicas.[10] These three, the galactometer of Dinocourt, the lactodensimeter of Quevenne, and the lactometer of Dicas, corresponded to the three well-known classes of aræometers, known as the percentage hydrometers, the density hydrometers and the specific gravity hydrometers respectively.[11] A brief discussion of each is apropos.

The lactometer of Dicas, devised prior to 1790, was a specific gravity hydrometer made of brass. It was provided with eight weights that could be dropped on to a stem below the bulb, as might be needed to sink the lactometer until the upper stem only was cutting through the meniscus of the milk. The reading on the upper stem, added to the number on the weight used, gave the specific gravity that was sought. This lactometer was provided separately with a thermometer and a slide rule for reducing the readings to 55° F. The advantage of this type of construction is that for a given openness of scale, a wide range of specific gravities may be covered with a very compact aræometer. If one were bent on using one and the same instrument for ordinary milk and for evaporated and condensed milks, then Dicas's lactometer would serve his purpose. But experience has since shown that the range of specific gravities in ordinary milk work is quite narrow, and the wide range lactometer of Dicas is not there needed.

The lactodensimeter of Quevenne was a density hydrometer, and with it in 1841 Quevenne gave also a scientific foundation for lactometry that has been forgotten. But as to the dimensions of his lactodensimeter, Quevenne was evasive. There is an authoritative cut of it in a monograph[12] gotten out in 1857 for the instruction of government officials in the testing of milk, but again all dimensions are omitted. The cut does not show that the Quevenne instrument was a *thermo*-lactodensimeter.[13] Regarding its scale, Quevenne states:[14] "The figures . . . show exactly how much a liter of milk weighs more than a liter of distilled water. Thus at a reading of 30 at a temperature of 15° C., one liter of milk weighs 30 grams more than a liter of distilled water . . . that is to say, it would weigh 1030 grams." As soon as the readings are supplemented by a 10 placed in front of each reading, as Quevenne meticulously explains, the readings of the true Quevenne lactodensimeter become statements of densities in grams per liter. When divided by 1000, these numerical statements of densities in grams per liter become numerical statements of the specific gravities at 15°/4° C. Judged from Quevenne's precise thinking, the market offering today of so-called Quevenne lactometers and modifications appears as a hodge podge of aberrant mongrels, mostly nondescripts. This hybrid multitude may have come into existence largely because of the prevailing ignorance of Quevenne's conceptions and because of the evasion Quevenne was guilty of when he limited his description of the proportions of his lactodensimeter to a statement to the effect that he and Chevallier had "in a definite way" settled upon its form, dimensions, and scale.

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[6] Amer. Chemist, I, 2, Aug., 1870. p. 41. Cf., 4th Ann. Rep. N. Y. State B. of H., p. 299. 1884.

[7] Ann. d. hygiène publique et de médecine légale, XXVI, 1841. Note 5, p. 45. T. A. Quevenne's papers cover pp. 1–125 and pp. 257–380.

[8] Lab. Manual, "Methods of Analysis of Milk and its Products," compiled by International Association of Milk Dealers, Chicago, 1933. p. 180. Also, Heineman, "Milk," Philadelphia, 1919. p. 143.

[9] P. 12, l. c., footnote 7.

[10] W. Garnett, Article "Hydrometer," Ency. Brit., 9th Ed., 1881. XII, p. 536.

[11] V. Stott, Article "Hydrometers," Glazebrook's Dictionary Appl. Physics, London, 1923. III, p. 432.

[12] Instruction pour l'essai et l'analyse du lait. A. Bouchardat & T. A. Quevenne. Paris, 1857. p. 5.

[13] A combined lactometer and thermometer.

[14] P. 61, l. c., footnote 7.

The galactometer of Dinocourt was a percent hydrometer. Known today as the New York Board of Health lactometer, it is probably the most used of all lactometers throughout the United States.[15] I think its popularity may be traced to its conveniently large size, its consequent ruggedness of construction, and its openness of scale. Among chemists its readings would be (but they never are) correctly spoken of as *degrees Dinocourt*, just as readings on the saccharometer are spoken of as *degrees Brix*. There can be little doubt that Dinocourt set out with a misconception of lactometry,[16] and then tried to solve a problem in an indirect way that is mathematically impossible.[17] But, "A friendly eye could never see such faults."[18] Its fundamental weaknesses are, however, clearly recognized in England; and of this popular New York Board of Health lactometer a great English authority wrote: "Another form of lactometer, the name of whose inventor is deservedly lost in oblivion, has a scale from 0 to 100, 0 being equal to the specific gravity of 1.000 (water), and 100 being equal to a specific gravity of 1.029. It is of no practical use in milk testing."[19]

Of the three well-known classes of hydrometers, only the specific gravity hydrometer relates directly to the present-day problem of a rational lactometer. In America the use of the specific gravity of milk at 60° F. referred to water at 60° F. must be taken as an accomplished fact.[20] The instrument herein described is therefore not a modified Quevenne, or a modified Dinocourt, but, if it must be classified, it belongs in the same class as the Dicas instrument.

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[15] Prof. Babcock referred to the New York Board of Health lactometer as "the ordinary lactometer," p. 300, l. c., footnote 2.

[16] Dinocourt assumed that any and every pure milk had a specific gravity of 1.029.

[17] The Dinocourt galactometer was presupposed to read % milk in any mixture of milk and water. Using the average value for the percentage of water in pure milk, its reading may readily be changed into % total water present in the mixture of milk and water. This figure subtracted from 100% equals the % total solids in the mixture. Since the % total solids in such a mixture is a function of both the specific gravity and the butter fat, it would be impossible to learn its value from the (ideal) Dinocourt galactometer reading, because it is algebraically impossible to solve for one of three interdependent variables when only one equation connecting them is known.

[18] Julius Caesar, Act IV, Scene III.

[19] H. Droop Richmond, Dairy Chemistry, 3rd Ed., London, 1930. p. 73.

[20] See, Standard Methods of Milk Analysis of A.P.H.A. & A.O.A.C., 6th Ed., New York, 1934. p. 77. How and when the change from 15°/4° C. to 15.56°/15.56° C. took place I have as yet not been able to determine. Domke & Reimerdes state that in Germany the Quevenne instruments received for correction read 15°/15° C. (See Domke u. Reimerdes, Handbuch der Aræometrie, Berlin, 1912) So this is not merely an American convention. V. Stott says (l. c., footnote 11): "It was formerly more customary to express the results (in hydrometry) relative to water at the same temperature as the liquid under investigation." It may well be that the makers of hydrometers have held their own and that Quevenne's scientific reform never actually became established among them.

Disregarding the great loss by abandoning Quevenne's basis of density at 15°/4° C., it is still of importance to see what differences in specific gravity follow from the changes in temperature of reference. Lactometers with graduations for readings at various temperatures are sometimes met with. A milk reading 1.0330 at 60°/60° F. would read 1.0320 at 15°/4° C. Milks reading 1.0330 at 60°/60° F., which is 15.56°/15.56° C., still read 1.0330 on lactometers graduated for 15°/15° C. which is 59°/59° F. See last paragraph of this paper.

The combined use[21] of butter fat percentage and lactometer reading was forced upon chemists as the proper basis for routine milk analysis at least as early as 1841, in the days when the methods for the determination of butter fat were still quite primitive. Quevenne's joint use of the lactodensimeter and creamometer, Bouchardat & Quevenne's joint use of the lactodensimeter and lactoscope, Chandler's joint use of the galactometer and "lactometer"(?), all show the recognition of the functional dependence of the solid content of a milk upon both the density and the butter fat. The quantitative (algebraic) statement of this functional interdependence had to await the development of a rapid accurate method for determining butter fat, and equations expressing this relationship satisfactorily followed closely upon the discovery of the Babcock centrifugal method.[22] From the point of view of these equations, the essential difference in the lactometers on the market today is the difference in sensitiveness; differences in size, shape, inscription of scale, etc., are all less important differences without fundamental significance. There must be some desirable, though unknown, sensitiveness for a lactometer for present day usage; all more sensitive lactometers are then hyper-sensitive, and all less sensitive lactometers are then hypo-sensitiveness. The gist of this paper is the search for this ideal sensitiveness, and the building up thereupon of a lactometer best adapted to current needs.

It is taken as axiomatic that the unknown desirable sensitiveness for the lactometer should be learned from the equation for routine milk analysis,[23] namely,

$$\text{T.S.} = 0.25\ \text{L} + 1.2\ \text{F} + \text{k} \quad \ldots\ldots\ldots\ldots (1)$$

After transposition and clearing of fractions, a partial differentiation of equation (1) gives,

$$\text{dL} = -4.8\ \text{dF} \quad \ldots\ldots\ldots\ldots (2)$$

Obviously, when the variable T.S. was "held fast," differentiation yielded a linear equation. Therefore the allowable reading-error (stated in units of L) may be 4.8 times the routine error in reading the fat in units of F, without changing the calculated T.S. value more than this T.S. value would have been changed had the L-reading been errorless and the F-reading affected by the average error incident to the use of the Babcock centrifugal butter fat method.

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[21] As is well known, judicious skimming and watering of the same milk will leave the lactometer reading of the milk unchanged.

[22] The simple form of the milk equation is often called Richmond's, or Richmond & Hehner's, or Babcock's formula. As a matter of fact it is an arithmetically simpler form of expression that became apparent when more complicated formulæ were applied and the tabulated results therefrom calculated were compared. See Richmond's Dairy Chemistry, 2nd Ed., 1914. p. 69; and Shaw & Eckles, l. c., footnote 3.

[23] It is immaterial for present purposes whether the constant k is made equal to 0.14 or to some other value such as 0.10, or to zero, because in the partial differentiation of this milk equation the added constant disappears. In this country it is customary to drop the constant, as suggested by Patrick (see Leffmann, Analysis of Milk & Milk Products, Philadelphia, 1915. p. 21).

The best method for arriving at a probable value for this constant in the milk equation has been laid down by Overman, Davidson & Sanmann, Illinois Agr. Exp. Station Bulletin 263, 1925, pp. 263–271, in an article, "Relation of Solids in Milk to Fat & Specific Gravity of the Milk." Their result, k=0.105, for mixed milks from many cows, may be looked at somewhat askance by many statisticians because only 174 samples of mixed milks were used in arriving at this value.

Taking the routine Babcock error, B, as 0.1%,[24] the reading-error on the lactometer, E, may be allowed to amount to as much as 4.8 times 0.1, or 0.48 lactometer unit.

When the openness of scale, O, is insufficient, a less certain scale reading along with a shorter scale-length S results; when excessive, a more certain scale reading along with a longer scale. The U. S. Bureau of Standards recommends[25] 0.5 to 1.0 mm. for the length of the smallest scale division on any hydrometer scale.[26] With these figures taken as reasonable limits conformable to the vision of the average operator, and with the approximate average of these equated to the allowable reading-error on the lactometer, the corresponding conformable length of scale can be arrived at directly. Thus,

if 0.48 of the lactometer unit be made equal to 0.08 cm.,
then 1.00 of the lactometer units would equal 0.08/0.48 cm.,
and 42.00 of the lactometer units would equal 7.00 cm.

Hence for a scale that will read quite satisfactorily, the scale-length from 0 to 42 lactometer units figures out as being 7 cm. over-all. The idea here involves making *one whole easily read distance* equal to the allowable error in reading it upon a lactometer scale, so that if one should happen to misread the lactometer by *one whole easily read distance* or any thing less than that, this could happen without any necessity for considering the effect of this error in reading upon the final calculated result for percentage of total solids. This scale should then be satisfactory from the points of view of the error in reading butter fat and of the difficulties in reading hydrometers.

But most chemists seem to prefer hyper-sensitive physical apparatus; few, do not. By multiplying this scale length by any selected *factor of satisfaction*, f, the scale length may be accommodated to any personal preference as to sensitiveness. In the instrument shown in the cut, Fig. I, it seemed wise to take this factor as equal to 1.5. Then,

$$S = 1.5 \times 7 = 10.5 \text{ cm.}$$

Of course where no such satisfaction is allowed for, there $f=1$.

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[24] See A. C. Dahlberg, "Variations that may reasonably be expected in butter-fat tests," Ann. Report New York State Assoc. Dairy & Milk Inspectors, VI, 1932. p. 191. Cf. Chem. Abstracts, XXVIII, 5143, Aug. 20, 1934: "The experimental error of the butterfat determination as conducted on the same sample in different laboratories is 0.2%."

[25] "The Testing of Hydrometers," Circular of the U. S. Bureau of Standards No. 16, 5th Ed., 1922.

[26] The subdivisions on the scale of a lactometer may be equal to each other in length, or unequal. Whether the scale should be laid off in distances from the lower mark that are in a decreasing arithmetical progression or in an harmonic progression had to be decided in the present case. The matter was first determined approximately by direct reasoning, and later checked by use of the procedure laid down by Domke & Reimerdes in their fundamental equation for aræometers (see reference in footnote 20). On the scale proposed later in this paper, the length of a whole lactometer unit is 2.500 mm.; while in using an harmonic graduation for this scale the maximum variations from this value would have ranged from +0.037 to −0.035 mm. It was therefore proper to use the arithmetic scale for this lactometer.

On the stems of a group of different lactometers, the differences among the openness of the portions from 1.020 to 1.021 and from 1.035 to 1.036 varies directly as the mass of the lactometers and inversely as the squares of their diameters of stem. It should be observed therefore that on the (California) State lactometer of Dr. Stone, the diameter of the stem of which is approximately 2.8 mm. and the mass of which is about 47 grams, the graduations are in harmonic progression. This is the characteristic of the State lactometer. Except as to size, it seems otherwise indistinguishable from the U. S. Department of Agriculture lactometer of Shaw & Eckles. The Shaw and Eckles lactometer has an arithmetic ruling in all the samples I have seen, while the average diameter of stem is about 3.4 mm. and the average mass about 72 grams.

To develop the lactometer, an instrument may be imagined consisting solely of bulb and stem, each of which is a cylinder of uniform cross-section. The provisional scale readings on this stem may be assumed to begin exactly where the bulb ends and the stem begins, and to include all readings from the 42-reading to the 0-reading. By Archimedes' Principle, the weight of the water[27] displaced when this instrument sinks in water to its 0-reading must exactly equal the weight of the heaviest milk displaced when it sinks in the heaviest milk to its 42-reading, i. e., when all of the bulb but none of the stem is immersed in the heaviest milk, milk of Sp. Gr. 1.042 at 60°/60° F. The weight of this milk displaced by the bulb will then exactly equal the weight of the water displaced by the bulb plus the weight of the water displaced by the stem. Then when all are at 60° F.,

if M_b = the weight of the milk displaced by the bulb,
and W_b = the weight of the water displaced by the bulb,
and W_s = the weight of the water displaced by the stem,

$$M_b = W_b + W_s \quad ,$$

and

$$W_s = M_b - W_b \quad .$$

Now taking V_b and X as the volumes of the bulb and stem respectively, and recalling that in lactometry the weight of unit volume of water at 60° F. is taken as unity, it follows that

$$W_s = 1.042V_b - 1.000V_b = 0.042V_b \quad .$$

Again, since the weight of unit volume of water at 60° F. is taken to be unity, then

$$W_s / 1 = X,$$

hence

$$X = 0.042V_b \quad .$$

In words, the volume of the stem of this lactometer from the 42-reading to the 0-reading must be equal to forty-two one-thousandths of the volume of its bulb, regardless of the size of the bulb. Then

$$X = \pi r^2 h \;^{28}$$

$$X = 3.14 \times \frac{D^2}{4} \times 10.5$$

$$X = 8.247 D^2 \quad .$$

and, from above,

$$X = 0.042 V$$

where V is now used instead of V_b to represent the volume of the bulb.

Equating the last two values and then solving for the stem-diameter, it follows that,

$$D = 0.07136 \sqrt{V} \text{ centimeters.} \quad \ldots\ldots\ldots\ldots (3)$$

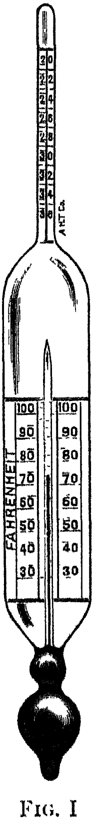

FIG. I

The constant of proportionality that appears in equation (3), namely, 0.07136, combines several constants some of which have been selected in a way that might be regarded as too arbitrary. Those who do not concur in the choice of 0.1%, 0.8 mm., and 1.5

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[27] The lactometer is usually immersed in two fluids, the bulb and more or less of the stem in milk, and the rest of the stem in air. The variable immersion in air unquestionably disturbs somewhat the weight of the lactometer. The size of this effect was calculated for the largest (bulb) and smallest (bulb) lactometers met with among the commercial samples I examined. The bulbs ranged from 100 cc. to 23 cc. in displacement. The information gained is of interest as showing the likely magnitude and the practical insignificance of this factor of error in lactometers as they are at present made. The maximum percentage change in weight due to immersion in both milk and air worked out as 0.0020% for the instrument with the largest bulb, and 0.0018% for the one with the smallest bulb.

[28] The usual formula for the volume of a right circular cylinder.

may select their own values for these constants and substitute them into the more general form of equation (3), namely,

$$D = 0.2473 \sqrt{\frac{B}{O \times f}} \times \sqrt{V} \text{ centimeters.} \quad \text{..........} (4)$$

For routine milk work it is unnecessary for the scale to read outside the limits 20 to 36[29] on the lactometer. A small departure from the exact coincidence of the (hypothetical) zero mark with the point of attachment of stem to bulb may be compensated, without significant effect upon the results already stated, by ballast added or removed in manufacture. The sealing off of the top of the stem, and other details, follow the general suggestions of the Bureau of Standards for hydrometers.[30] Subdivisions of the units in the scale based upon equation (3) may be made, provided the minimum length for a scale division as set down by the Bureau of Standards be borne in mind. Thus, in the instrument shown in the cut, each lactometer unit has been subgraduated into fifths, each smallest subdivision on the scale then having an openness of 0.5 mm. If this scale is actually read to fifths, as it may be by those of excellent vision, it will permit readings more than twice as closely as equation (2) demands; ordinarily the instrument need be read only to within two fifths of a lactometer unit.

Whether equation (3) be adopted or some other equation derived from equation (4) be adopted, a plotting table and a graph made from the equation will prove useful.[31] It may well be that there are lactometers upon the market or in actual use that will, by coincidence, happen to meet the requirements of the equation adopted. The graph made from the plotting table will make it possible to determine the fitness of any lactometer as measured by the requirements of the equation adopted.

The plotting table from equation (3) and the corresponding graph are given in Table I and in Fig. II, respectively. In Fig. II the co-ordinates of any point are the volume of the bulb, V, and the diameter of the stem, D. Plotted upon paper ruled in millimeters, the diameters of the stems may conveniently be plotted as ordinates of which each centimeter of length represents one millimeter of diameter of stem, and the volumes of the bulbs as abscissae of which each millimeter of length represents one cubic centimeter displacement by the bulb. In the case of any lactometer one may desire to examine, it will suffice to obtain the value for the volume of its bulb by noting the change in reading upon the scale of a graduated cylinder containing any suitable liquid when the bulb of the lactometer is immersed in the liquid; the diameter of the stem may be obtained by measurement with a vernier caliper or micrometer caliper.[32] If the point found upon the graph by use of these co-ordinates is located above the curve of the equation, the instrument is hypo-sensitive; if below, the instrument is hyper-sensitive, as judged by the sensitiveness specified by the equation.

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[29] Richmond adopted these limits years ago for his slide rule for finding the percentage of total solids when the lactometer reading and the percentage of fat are known. In his extended "Dairy Scale" developed later, the specific gravity scale was extended to 1.038. See p. 474, l. c., footnote 19.

[30] See footnote 25.

[31] The plotting table and graph are confined to the part of the parabola located in the first quadrant.

[32] The average value for the diameter had best be used. I have met with variations upon one and the same lactometer stem that ranged from 0.3% to 4.3% of the total diameter.

TABLE I

(Plotting table for Equation 3)

Volume of Bulb Cc.	Diameter of Stem Cm.
100	.71
95	.70
90	.68
85	.66
80	.64
75	.62
70	.60
65	.58
60	.55
55	.53
50	.51
45	.48
40	.45
35	.42
30	.39
25	.36
20	.32
15	.28
10	.23
0	.00

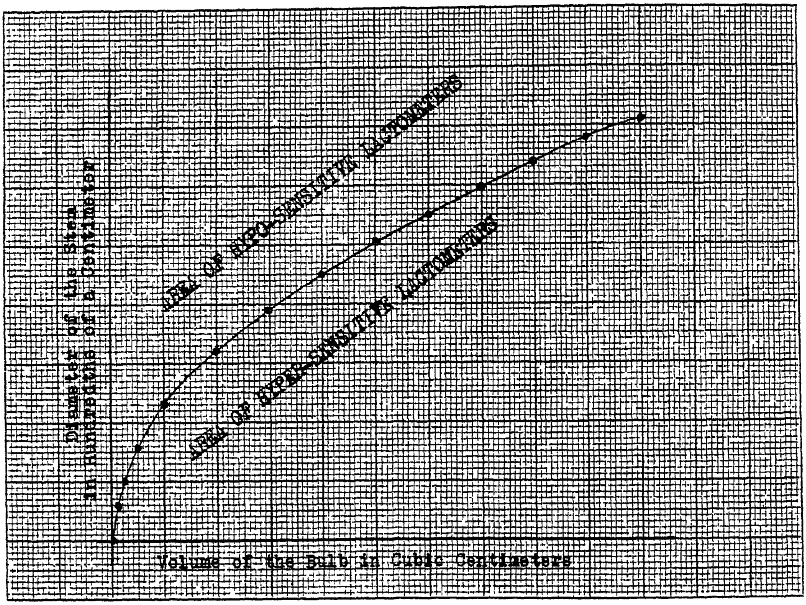

FIG. II

Using equation (3), the Quevenne lactometers (so-called) of the trade were found to be about three-fourths as sensitive as they should be[33] for sufficiently accurate work in calculating total solids by equation (1). The New York Board of Health lactometers of the trade were found to possess about half again the necessary sensitiveness. The "suitable proportions" recommended by Dr. Babcock gave an instrument of about five-sixths the necessary sensitiveness.[34] The U. S. Department of Agriculture lactometers[35] showed about nine halves the necessary sensitiveness, as did also the (California) State lactometer recently described by Dr. Stone.[36] Regardless of what values are adopted for the constants in equation (4), these measurements upon the ordinary articles of commerce show clearly the prevalent confusion ingrained in lactometry to date.

In the instrument developed for general use and shown in the cut, Fig. I, I have followed largely my own experience. The popular New York Board of Health type usually has a bulb displacement of 75 or 100 cc. Stems too small in diameter are fragile. Stems disproportionately thin for weighty bulbs, as in the U. S. Department of Agriculture lactometer of Shaw & Eckles and the (California) State lactometer of Stone, are likely to break out from the bulb at or near the seal where the stem is joined to the bulb. As I prefer a thermolactometer, and as the enclosed thermometer required a bulb 7 cm. in inside length,[37] the external length to include both thermometer bulb and bulb for ballest has to be about 10 cm.

[33] The lack of sensitiveness of the Quevenne instrument for present purposes apparently was recognized by Soxhlet at the time that milk formulas were being developed. For, at that time, Soxhlet brought out a thermo-lactodensimeter such that "auf 1° eine Lange von ca. 7.5 bis 8 mm. entfallt." The corresponding quantity on the Quevenne instruments, Domke & Reimerdes state, lies between two graduations removed only about 2 mm. from each other. Cf. Domke & Reimerdes, p. 167, l. c., footnote 20. Richmond, pp. 72–73, l. c., footnote 19, speaks of the Soxhlet lactometer as one of the three best and says it "may conveniently be used when great accuracy is required." However, the Soxhlet thermo-lactodensimeter is not commonly offered for sale in the U.S.A.

[34] Dr. Babcock's statement is: "A bulb one and one-eighth inch in diameter and three inches long, with a stem one-fourth inch in diameter gives suitable proportions for a dairy lactometer"; p. 301, l. c., footnote 2.

[35] Shaw & Eckles, under the impression that "the lactometers in common use are not sufficiently sensitive to be used in connection with the Babcock fat test for estimating total solids by formula" (l. c., footnote 3) increased the size of the bulb and decreased the diameter of the stem until they developed a lactometer that was very fragile but would yield results as accurate as those obtained with the Westphal balance. There was a paradox in this which they may not have recognized, as they make no mention of it. Since in the milk formula the lactometer reading and the butterfat have to be used *jointly*, what they did amounted to elevating one of these measurements to an excessive degree of accuracy as judged by the degree of accuracy possessed by the measurement of butter fat, with which it had to be used. They refined to one unit in the first decimal place the lactometer reading which upon entering the formula is at once divided by four, while the Babcock figure to which it is immediately added in the milk formula is a figure which at the start is only accurate to one or two units in the first decimal place and which in the formula is multiplied by six fifths. It does seem that to improve the results calculated from such a formula one would proceed in just the opposite way. As to the probable accuracy of the Babcock centrifugal method for butter fat, see footnote 24.

[36] The (California) State lactometer of Dr. Stone involves the same paradox as that in the U. S. Department of Agriculture lactometer of Shaw & Eckles brought out in footnote 35.

[37] Unless the thermometer scale is placed within the bulb of the lactometer, the Bureau of Standards advises that it must lie "beyond the hydrometer scale." This unduly prolongs the stem and detracts from the ruggedness of the instrument. When the accuracy of the thermometer must be determined by the purchaser

Accepting the value gotten from equation (2) of 0.48 of a lactometer unit as a permissible error in lactometer reading, an important conclusion regarding temperature corrections[38] according to Richmond's table for this purpose follows. For all instruments that are at least as sensitive as the instrument shown in the cut, Fig. I, and the other instruments that meet the requirements of equation (3), and for all instruments that are hyper-sensitive as compared with these, it is useless to correct the lactometer reading in all cases where the temperature of the milk is not below 58° F. and not above 62° F. For readings that do not lie outside of the limits fixed by the 25 and the 31 inscriptions upon the lactometer scale, it is justifiable to extend this generalization to measurements in all milks having temperatures not below 56° F. and not above 63° F. This allows a radical change in the current practice, which at present calls for the correction of all lactometer readings for all differences in temperature from the standard temperature of 60° F.

(Footnote continued from p. 9)
the scale should include both the ice-point and the boiling-point of water, and this necessitates blowing suitable enlargements upon the capillary. The graduations should show:

(a) every degree from 30 to 34,
(b) every degree from 40 to 80,
(c) every degree from 210 to 214.

As the graduations for each degree should be 1 mm. long, and as the thermometer is to have 48 graduations and 2 enlargements upon the capillary for each of which 1 cm. should be allowed, it follows that the part of the lactometer bulb containing the scale of the thermometer must be about 7 cm. long. Of course, the accuracy of the thermometer may be guaranteed, or it may be checked by comparison with a standard thermometer, in which cases the construction may depart from the rules just laid down.

[38] Milks are more frequently read when their temperatures are other than 60° F., and Tables based upon the apparent coefficient of expansion of milk in glass are generally available for correcting the observed reading to 60°/60° F. These Tables are of necessity highly arbitrary, resting as they do upon an assumed *fixed* value for the coefficient of expansion of milk. Richmond's Table rests upon the coefficient of expansion of a milk of specific gravity 1.032, and containing 3.8% butter fat. In routine work in milk control, Richmond's table is all that could be desired. But one must not lose sight of the fact that the expansion of rich milk is greater than that of poor milk. For example, in milks from which significant parts of the butter fat have been removed, one is dealing with something quite different from milk of specific gravity 1.032 containing 3.8% butter fat.

PUBLICATIONS OF THE INSTITUTE

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BULLETIN

Bulletin of the Institute. Quarterly $1.00 per year
Single numbers, 25 cents.

Republication of Conrad's Fossils of the Medial Tertiary of the United States. Introduction by *William H. Dall.* (Out of Print.)

BULLETIN
of the
WAGNER FREE INSTITUTE OF SCIENCE
PUBLISHED BY THE INSTITUTE
SYDNEY L. WRIGHT, *Editor*

Vol. 10
No. 2
Quarterly
May, 1935
$1.00 per year

SOME NEW BRUNSWICK CAMBRIAN AGNOSTIANS

BY BENJAMIN F. HOWELL, A.M., PH.D.

No group of trilobites is more interesting to the paleontologist or more potentially valuable to students of Early Paleozoic stratigraphy than the Agnostians. Members of this order of tiny crustaceans are found in Cambrian and Ordovician strata throughout the world, and some of the genera are so widely distributed geographically that their species will undoubtedly prove, when they are better known, to be of great value for long distance, as well as local, correlation.

The writer has been studying the Agnostians for many years. He hopes to make available to other stratigraphers additional information concerning them which will make them easier to use as time indicators, and has, himself, made much use of them in the correlation of many of the Cambrian formations of North America on which he has worked. He has recently found certain species to be such important zone fossils in some of the Middle and Upper Cambrian beds of New Brunswick, Canada, which he has been studying that they have seemed to be the logical ones to choose as the chief index fossils of those zones. As reference will be made to these zones and their index fossils in a memoir on the geology of the St. John region of New Brunswick, written by Professor A. O. Hayes and himself, which will go to the printers soon, it has seemed desirable that he should publish at this time the description of the one new species and 4 new genera of Agnostians involved.

The reference of these 4 new genera to families will be postponed until a later date.

All the genera and species discussed here are of Medial Cambrian age except the genus *Homagnostus* and the species *Homagnostus obesus*, which are Late Cambrian.

GONIAGNOSTUS, NEW GENUS

Agnostians with well developed dorsal furrows, glabellas, and pygidial axes, with the anterior lobe of the glabella pointed in front and the cheeks divided by a medial furrow, with the pygidial axis long and pointed at the rear, and with distinct transverse furrows on the glabella and the axis. In the known species of the genus the cheeks are crossed by furrows, the surface of the lateral lobes is granulated, the main lobe of the glabella has two indentations on each side behind the transverse furrow, and the flange of the pygidium has a spine at each rear corner; and these features are probably characteristic of the genus.

The genotype is *Agnostus nathorsti* Brögger, from the Middle Cambrian of Norway. *Agnostus sulcatus* Illing, from the Paradoxides Beds of England is also placed in the genus. The form which Matthew described from the Middle Cambrian rocks of New Brunswick as *Agnostus nathorsti confluens* is likewise referred to this genus, and is awarded full specific rank.

Goniagnostus is known to range through much of the Medial Paradoxidian *Paradoxides hicksi* Zone and the Late Paradoxidian *Paradoxides davidis* Zone of the North Atlantic Basin. It is not known from any other horizons or any other part of the world

TRIPLAGNOSTUS, NEW GENUS

Agnostians with well developed dorsal furrows, glabellas, and pygidial axes, with the anterior lobe of the glabella pointed in front and the cheeks divided by a medial furrow, with the pygidial axis long and bluntly pointed at the rear, and with distinct transverse furrows on the glabella and the axis. In the known species the test is smooth and the flange of the pygidium does not bear spines, and these features are probably characteristic of the genus.

The genotype is *Agnostus gibbus* Linnarsson, from the Middle Cambrian of Sweden. The forms described by Matthew from New Brunswick as *Agnostus gibbus acutilobus* and *Agnostus gibbus partitus*, and the form described by Brögger from Norway as *Agnostus gibbus hybrida*, are also referred to this genus. All these forms are of Medial Cambrian age.

Triplagnostus is known to have ranged through most of Paradoxidian time. Its species are characteristic members of *Paradoxides* faunas on both sides of the North Atlantic. One new form believed to belong in the genus is characteristic of one of the latest *Paradoxides* faunas of New Brunswick. It is described below.

TRIPLAGNOSTUS LOMONDENSIS, NEW SPECIES

Figs. 7, 8

Cephalon. The dorsal, medial, and transverse furrows are clearly, but not deeply, developed. The anterior end of the glabella is so bluntly rounded that only a trace of the pointing which is characteristic of *Triplagnostus* is present in the single known adult cephalon. (Two young cephala referred to the species have more pointed glabellas, however.) The brim is of low convexity and the basal lobes are of medium size. The whole shield is of rather low convexity and its surface is smooth.

Thorax. Unknown.

Pygidium. Somewhat more convex than the cephalon, with a smooth test and a flange which is of about the same width and convexity as the brim and shows no trace of spines. Dorsal and transverse furrows clear, but not deeply impressed. Axis lanceolate, acutely, but not sharply, pointed at the rear, and rising only very slightly above the general convexity of the shield. The middle lobe bears an elongated, keel-shaped, tubercle, which rises only a little above the general level of the shield. The cheeks are rather widely confluent behind the axis.

Remarks. This is a large species. It is characterized by the blunt anterior end of its glabella and the fact that its pleural lobes are widely confluent behind the axis.

Location of types. The holotype is a pygidium, no. 41761a in the paleontological collection of Princeton University. Paratype cephala are nos. 41761b-c and 41762a-c in the same collection.

Horizon and locality. The species has been found only in a single outcrop of late Medial Paradoxidian Cambrian black shale, holding thin lenses of dark gray limestone, on the southeastern side of the road which parallels the southeastern shore of Loch Lomond, near St. John, New Brunswick.

Tomagnostus, New Genus

Agnostians with well developed dorsal and transverse furrows, glabellas, and pygidial axes, with the front end of the anterior lobe of the glabella indented by a furrow lying on the axial line, and with a triangular, rather bluntly pointed pygidial axis, and no true medial furrow or spines on the flange. The cheeks are usually more or less furrowed, but the rest of the test is smooth.

The genotype is *Agnostus fissus* Lundgren, M. S., from the Middle Cambrian of Sweden, whose description was published by Linnarsson.

The genus is a characteristic one of the Middle *Paradoxides* Beds of both sides of the North Atlantic Basin.

Homagnostus, New Genus

Agnostians with well developed dorsal and transverse furrows, a smooth test, a bilobed glabella, which is somewhat, but not acutely, pointed in front, a rather faint medial furrow on the cephalon, and a large pygidial axis, whose rear lobe is more or less semiglobular in shape.

The genotype is *Agnostus pisiformis obesus* Belt, which is here raised to specific rank.

This is a characteristic genus of the lower Upper Cambrian beds of both sides of the North Atlantic Basin.

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Tullberg, S. A.: Om Agnostus-arterna i de kambriska aflagringarne vid Andrarum. Sveriges Geologiska Undersökning, Ser. C., No. 42, 1880, p. 1–37, 1 table, 2 pls., 1 map.

Figs. 1, 2: *Goniagnostus nathorsti* (Brögger), X 4, from the *Paradoxides tessini* Zone of Krekling, Norway.

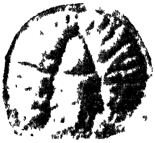
Figs. 3, 4: *Goniagnostus confluens* (Matthew), X 4, from the *Paradoxides abenacus* Zone of Porter's Brook, New Brunswick.

Figs. 5, 6: *Triplagnostus gibbus* (Linnarsson), X 4, from the *Paradoxides* Beds of Altorp, Sweden.

Figs. 7, 8: *Triplagnostus lomondensis*, new species, X 4, from the late *Paradoxides* beds beside Loch Lomond, New Brunswick.

Figs. 9, 10: *Tomagnostus fissus* (Lundgren, M. S.), X 4, from the *Paradoxides tessini* Zone of Andrarum, Sweden.

Figs. 11, 12: *Homagnostus obesus* (Belt), X 4, from the Upper Cambrian of Andrarum, Sweden.



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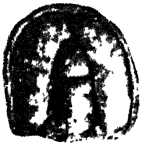

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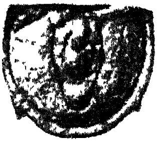

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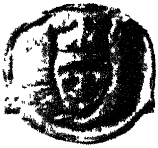

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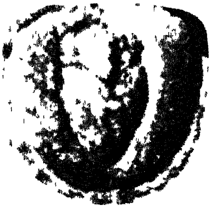

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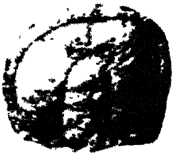

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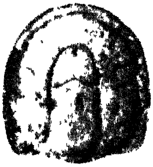

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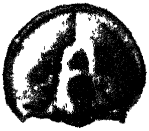

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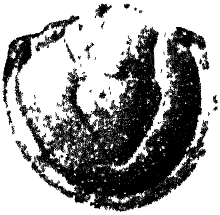

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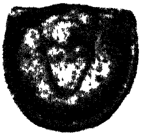

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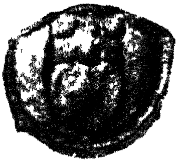

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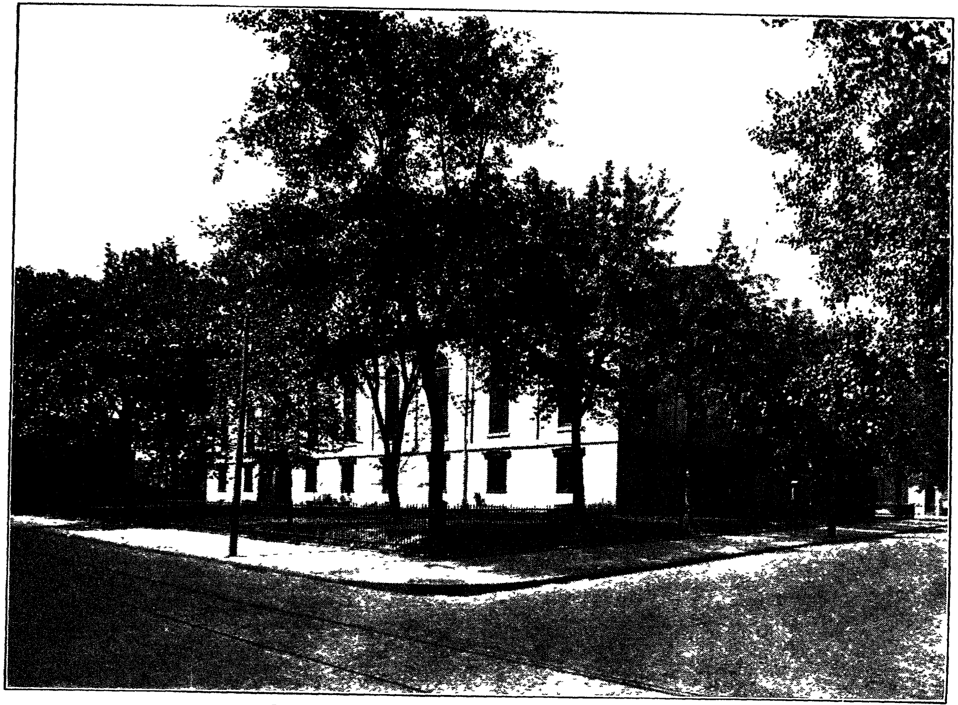

THE WAGNER FREE INSTITUTE OF SCIENCE

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of the
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PUBLISHED BY THE INSTITUTE
SYDNEY L. WRIGHT, *Editor*

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HISTORY

The Wagner Free Institute of Science was founded in 1847 by William Wagner, a citizen of Philadelphia.

In his early life William Wagner became associated with Stephen Girard in the extension of Girard's mercantile business. While in Girard's employ he had the opportunity to visit foreign countries, and being interested in scientific pursuits, he made a study of scientific institutions abroad and collected natural history specimens which afterward formed the nucleus for the collections in the museum of the Institute.

The Institute, itself, had its inception in a series of free lectures delivered by Professor Wagner in his home. These lectures, begun in 1847, were continued until 1855 when the Institute was incorporated by act of legislature.

A large measure of credit is due Mrs. Louisa Binney Wagner, Professor Wagner's wife, for sympathy, understanding and active coöperation in the early days of the founding of the Institute.

In 1855 a faculty was appointed and the work was continued in a new location at 13th and Spring Garden Streets, the City of Philadelphia giving permission for the use of Commissioners' Hall. Some years later Professor Wagner decided to erect a building on the present site at Seventeenth Street and Montgomery Avenue. This building was completed in 1865 and occupied immediately.

William Wagner died in 1885 and the management of the Institute was transferred to a Board of Trustees.

In 1901 a wing was added to the building for the use of a branch of the Free Library of Philadelphia.

INSTRUCTION

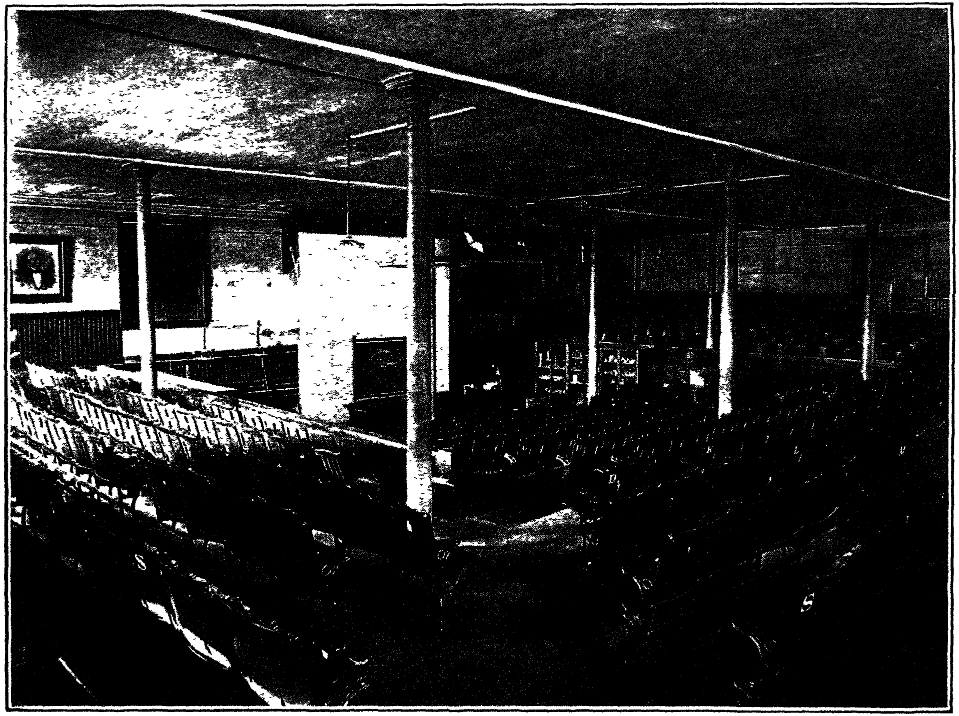
LECTURES AND CLASS-WORK

Instruction at the Wagner Free Institute of Science is conducted by means of lectures supplemented by class work. There are no tuition fees.

Persons may attend lectures without registering for the classes if they so desire. Those registering for the classes are required to hand in a weekly paper and are admitted to an examination at the end of the term. Those persons successfully passing the examination are awarded certificates for the year's work.

There are seven courses of scientific lectures covering a period of fourteen weeks each for four years. On the successful completion of four years' work a Full Term Certificate is awarded.

The closing of each lecture season is marked by Commencement Exercises.



Auditorium

MUSEUM

MUSEUM

The Institute maintains a natural history museum containing more than 21,000 specimens illustrating the various branches of natural science.

The collections are arranged especially for study. The museum is open to visitors on Wednesday and Saturday afternoons from 2 P.M. until 5 P.M., except legal holidays.

On each Monday evening at 7 P.M., from September to May, a "Museum Talk" is delivered in the museum, the speaker using the specimens in the museum to illustrate the lecture.

Teachers and students desiring to use the museum for special studies will be admitted upon application at the office.

LIBRARIES

The Reference Library of the Institute contains over 25,000 bound volumes and approximately 150,000 pamphlets on scientific subjects, classified and arranged for ready reference. There are also many foreign and domestic periodicals on file. The library is open to the public as well as to students from 10 A.M. to 9 P.M. daily, except Sunday.

The Free Library of Philadelphia maintains a branch library in the building, known as the Wagner Institute Branch, from which books may be taken out under the rules of the Free Library.

PUBLICATIONS

The publications of the Institute consist of three series:

Transactions: begun in 1885 and discontinued in 1927.

Publications: succeeding the Transactions. These Publications are issued at irregular intervals.

Bulletin: issued quarterly.

SPECIAL LECTURES

WESTBROOK FREE LECTURESHIP

The Westbrook Free Lectureship is supported by the income from an endowment provided by Dr. Richard Brodhead Westbrook and his wife, Dr. Henrietta Payne Westbrook. The lectureship was established in 1912 and provides for one course of lectures each year. These lectures cover a wide range of topics and a list of those so far given may be found on page 35.

FANNIE FRANK LEFFMANN MEMORIAL LECTURESHIP

The income of a fund given by Dr. Henry Leffmann is applied to occasional special lectures under the Memorial Lectureship. These lectures are popular in character.

The *Philadelphia Natural History Society* is affiliated with the Institute and holds meetings on the third Thursday of each month from October to May.

RESEARCH

The Institute has carried on research work since 1885 in various departments of science. Results of research have been published from time to time in the Transactions, Publications and Bulletin.

The Institute is also the recipient of the income from two funds established by Dr. Henry Leffmann. This income is devoted to research in chemistry.

CERTIFICATES AWARDED AT CLOSING EXERCISES, MAY 8, 1935

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William Mahn
Florence McIlravey
Owen J. McMenamin
Weldon A. Parks
John W. Quinn
William G. Ramsey
Benjamin N. Roberts
Albert J. Rosenheimer
Milton Selig
Mertice H. Speier
Margaretta Splane
George F. Stauffer
Lelia M. Stauffer
Charles F. Summers
Frank J. Thomas
Helen B. Vail
Samuel T. Woal
Sylvia B. Young

GEOLOGY 4

John H. Antrim
John Berninger
Myles Brazill
Robert J. Crawford
Rosanna I. Crawford
Beecher Finch
Wilma E. Gaines
R. Edythe Green
John F. Hardecker
Herman H. Hofeld
H. May Hunter
John J. Kane
Owen J. McMenamin
Louis Moyd
John W. Quinn
William G. Ramsey
Benjamin N. Roberts
Viola E. Rogers
Albert J. Rosenheimer
William E. Schlesman
Charles F. Summers
David Travis
John H. Turri
Helen B. Vail
David B. Walker
Samuel T. Woal
Sylvia B. Young

PHYSICS 1

Adele B. Arlan
Howard R. Atkinson
John Berninger
Myles Brazill
Norman P. Breyer
Burton J. Cherney
Beecher Finch
Joseph Fisher
Ludwig Frank
R. Edythe Green
Thomas H. Hart
Herman H. Hofeld
Roland W. Johnson
John J. Kane
William R. Mark
Louis Moyd
John W. Quinn
William G. Ramsey
Benjamin N. Roberts
Albert J. Rosenheimer
Edward W. Sanders
Charles F. Summers
David Travis
Thomas Willis, Jr.

FACULTY

SAMUEL CHRISTIAN SCHMUCKER

A.M., M.S., Sc.D., Muhlenberg College.
Ph.D., University of Pennsylvania.
Professor of Biological Sciences, State Teachers College, West Chester, Pa., 1895-1923.
Science Department, Summer Schools, Chautauqua, N. Y., 1906-1928.
Lecturer on Biology, Brooklyn Institute of Arts and Sciences, 1905-1933.
Professor of Botany, Wagner Free Institute of Science, 1908-1926.
Professor of Zoology, Wagner Free Institute of Science, 1926 to date.
Dean of the Faculty.
Author of
"The Study of Nature." (Lippincott Co., Philadelphia.)
"The Meaning of Evolution." (Macmillan Co., N. Y.)
"Man's Life on Earth." (Macmillan Co., N. Y.)
"Heredity and Parenthood." (Macmillan Co., N. Y.)

JOHN WAGNER, JR.

B.S. in C.E. 1913, University of Pennsylvania.
C.E. 1920, University of Pennsylvania.
Assoc. M., Am. Soc. C. E.
1913-1916, Draftsman, Phoenix Bridge Company.
1916-1921, Office of Engineering Bridges and Buildings, Pennsylvania Railroad, including two years' service with the Army as First Lieut. and Captain in the Cavalry.
1921-1926, Assistant Supervisor Track, Reading Company.
1926-1928, Supervisor Track, Reading Company.
1928 to date, Industrial Agent, Reading Company.
Professor of Engineering, Wagner Free Institute of Science, 1926 to date.

LESLIE BIRCHARD SEELY

Graduate, State Normal School, Bloomsburg, Pa.
Taught school, Luzerne and Snyder Counties, Pa.
Assistant instructor in physics and chemistry, Bloomsburg, 1899-1902.
Graduate, Haverford College, 1905.
Head Master, Friends Institute, Chappaqua, N. Y., 1905.
Instructor in physics, Northeast High School, Philadelphia, 1906-1915.
Head of Science Department, Germantown High School, 1915-1923.
Principal, Roxborough High School, 1923-1924.
Principal, Germantown High School, 1924 to date.
Graduate courses, University of Pennsylvania and Brooklyn Institute, 1906-1910.
Honorary degree of Doctor of Pedagogy, Ursinus College, 1926.
Professor of Physics, Wagner Free Institute of Science, 1912 to date.
Publications:
"Description of Two New Distomes," Biological Bulletin, Lancaster, Pa., 1906.
"Ether Waves and the Messages They Bring," Transactions of the Wagner Free Institute of Science.
"The Physics of the Three-electrode Bulb," Transactions of the Wagner Free Institute of Science.

DAVID WILBUR HORN

A.B., Dickinson College, 1897.
A.M., Dickinson College, 1898.
Ph.D., Johns Hopkins University, 1900.
Assistant in Chemistry, Johns Hopkins University, 1900-1901.
Associate and Associate Professor of Chemistry, Bryn Mawr College, 1901-1907.
Lecturer in Hygiene, Hahnemann Medical College, 1911 to date.
Head of Pre-Medical School of Science, Hahnemann Medical College, 1916-1921.
Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science, 1921 to date.
Professor of Inorganic and Physical Chemistry, Wagner Free Institute of Science, 1911 to date.

Chairman of Philadelphia Section of American Chemical Society, 1904 and 1905.
Fellow of American Association for the Advancement of Science.
Fellow of the Royal Society of Arts of London.

IVOR GRIFFITH

Early education at the Bethesda Academy, Wales, and came to America in 1907.
P.D., Philadelphia College of Pharmacy and Science, 1912.
Ph.M., Philadelphia College of Pharmacy and Science, 1921.
Sc.D. (Hon.), Bucknell, 1934.
Director of Research, John B. Stetson Company, 1925 to date.
Director of Laboratories, Stetson Hospital, 1920 to date.
Editor, American Journal of Pharmacy, 1921 to date.
Associate Professor of Pharmacy, Philadelphia College of Pharmacy and Science 1914 to date.
Professor of Organic Chemistry, Wagner Free Institute of Science, 1926 to date.
Secretary of the Faculty of Wagner Free Institute of Science.
Fellow of the American Institute of Chemists.
Fellow of the American Association for the Advancement of Science.
Fellow of the Pennsylvania Academy of Science.
Member American Chemical Society.
Publications:
  "Recent Remedies," 1926 (revised 1928). International Publications, N. Y.
  "Popular Science Lectures" (Editor) (twelve volumes). Phila. College Pharmacy and Science, Phila.
  U. S. Dispensatory (Collab. Editor). Lippincott, Phila.
  Formula Book, A. Ph. A. (Editor). Lippincott, Phila.
  Contributor to current chemical, pharmaceutical and medical literature.

GEORGE BRINGHURST KAISER

Educated in private schools.
Graduate, Franklin School.
After graduation spent several years in intensive botanical study and field work in northeastern United States.
Secretary of the Botanical Society of Pennsylvania for seven years and leader of its field trips.
Professor of Botany, Wagner Free Institute of Science, 1927 to date.
Curator, Moss Herbarium, Sullivant Moss Society.
Treasurer, Delaware Valley Naturalists' Union.
Member, Academy of Natural Sciences.

BENJAMIN FRANKLIN HOWELL

B.S., A.M., Ph.D., Princeton University.
Associate Professor of Geology and Paleontology, Princeton University.
Professor of Geology and Paleontology, Wagner Free Institute of Science, 1927 to date.
Curator of Invertebrate Paleontology and Stratigraphy in Princeton University.
Fellow of the Paleontological Society.
Secretary of the Paleontological Society.
Fellow of the Geological Society of America.
Fellow of the American Association for the Advancement of Science.
Member of the Palaeontologische Gesellschaft.
Associate Member of the Society of Economic Paleontologists and Mineralogists.
Member of the Committee on Micropaleontology of the National Research Council.
Chairman of Cambrian Subcommittee of U. S. National Research Council Committee on Stratigraphy.
Secretary of the Organization Committee of the International Paleontological Union.
Editor of the section of General Paleozoology of *Biological Abstracts.*
American Editor of *Palaeontologisches Zentralblatt.*
Specializes in Cambrian Paleontology and Geology.
Associated with U. S. Geological Survey, the U. S. National Museum, Geological Survey of Canada, Canadian National Museum, Geological Survey of Vermont, Geological Survey of Montana, Colorado School of Mines, as a consulting paleontologist and research associate.

REGULAR LECTURES, SESSION OF 1935-1936

BOTANY 1

PROFESSOR KAISER

Morphology

Lectures begin at 8 P. M.

1. Monday, September 9.
   Seed and Embryo. Parts and uses. Growth of seedling.
2. Monday, September 16.
   Root. Composition, duration and kinds. Special functions.
3. Monday, September 23.
   Stem and Bud. Subterranean and aerial stems. Kinds of buds.
4. Monday, September 30.
   Leaf. Parts, uses. Kinds and forms. Special functions.
5. Monday, October 7.
   Flower. Parts and their uses. Perfect and unisexual flowers.
6. Monday, October 14.
   Phyllotaxy and Anthotaxy. How leaves and flowers are placed on the stem and in the bud.
7. Monday, October 21.
   Fruit. Kinds, parts, source and development.
8. Monday, October 28.
   Pollination and Fertilization. Deposition of pollen on stigma and the fertilization which follows.
9. Monday, November 4.
   Cell. Form and composition. Contents and derivatives.
10. Monday, November 11.
    Mitosis. The process of indirect nuclear division and the Reduction form.
11. Monday, November 18.
    Differentiations of the Cell. Building the cell wall. Its constituents. Many kinds of cells.
12. Monday, November 25.
    Contents of the Cell. The manifold inclusions of the cytoplasm.
13. Monday, December 2.
    Tissues. Actively dividing and permanent. Epidermal, mechanical, conducting and secretory.
14. Monday, December 9.
    Aerial Stem. Distribution of xylem and phloem, medulla and medullary rays. Cambium, phellogen. Sap and heart wood.

Field Trip

The class in Botany will be conducted on a field trip under the leadership of Professor Kaiser. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

INORGANIC CHEMISTRY 3

PROFESSOR HORN

Descriptive Chemistry

Lectures begin at 7.45 P. M.*

1. Tuesday, September 10.
   Carbon. Sources, properties. Lampblack, graphite. Diamonds, real and artificial. Coal, petroleum, asphaltum, natural gas. Hydrocarbons, acetylene. Carbon tetrachloride. Carbides.
2. Tuesday, September 17.
   Carbon (Continued). Carbon monoxide; water gas, producer gas. Carbon dioxide, carbonates, bicarbonates. Carbon disulphide.
3. Tuesday, September 24.
   Inorganic Compounds of Carbon and Nitrogen. Cyanides, ferrocyanides, ferricyanides, nitroprussides. Cyanates, sulphocyanates. Cyanamide. Chemistry of blue-printing.
4. Tuesday, October 1.
   Silicon. Occurrence, preparation, properties. Silicic acids. Colloidal silicic acid. Silicates; glass, pottery, water glass. Silicon tetrafluoride. Fused quartz.
5. Tuesday, October 8.
   Significance of the term "Metal." Historical. Electromotive series. Noble and base metals. Metallic properties. Metallurgy. Metallography. Alloys. Amalgams.
6. Tuesday, October 15.
   Sodium. Salt, nitre, and borax. Leblanc and Solvay Processes. Sodium bicarbonate, carbonate, hydroxide, metal, oxide and peroxide. Baking powders, chemical fire-extinguishers.
7. Tuesday, October 22.
   Potassium, Rubidium, Caesium. Potash. Causticizing potash. The Stassfurt deposits, other sources of potassium salts. Saltpetre. Fixed alkalis. Hydrolysis. Spectrum analysis.
8. Tuesday, October 29.
   Lithium, Barium, Strontium. The metal lithium. Lithia waters. Barytes, precipitated barium sulphate. Lithopone. Barium oxides. Strontium salts. Fire-works.
9. Tuesday, November 5.
   Calcium. Limestone, other natural carbonates of calcium. Hardness in water. Limestone caverns. Gypsum, plaster of Paris. Mortar, cement. Bones, phosphate rock, fertilizers.
10. Tuesday, November 12.
    Magnesium and Zinc. Sources, preparation, properties. Magnesite, dolomites. Magnesium salts. Metallic magnesium and zinc. Industrial uses of the metals. Zinc white.
11. Tuesday, November 19.
    Aluminum. Occurrence, preparation, properties. The alums. Uses of metallic aluminum. Clay. Emery. Gems. The Goldschmidt Process, thermite. Lakes.

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* Please note the hour.

12. Tuesday, November 26.
Manganese and Chromium. Occurrence, preparation. Multi-valence. Manganese salts, permanganates. Manganese alloys. Chromium salts, chromates, and poly-chromates. Nichrome. Rustless steels.

13. Tuesday, December 3.
The Analytical Scheme of the Metals. The subdivision of the metallic ions into groups. Group separations. Sub-group separations. Confirmatory tests. Handling "Unknowns."

14. Tuesday, December 10.
Metal-Ammonia Compounds. Some complex ammonia compounds of mercury, copper, cobalt, nickel, platinum and chromium. Werner's Hypothesis. Stereo-isomerism in inorganic compounds.

ORGANIC CHEMISTRY 3

PROFESSOR GRIFFITH

Cyclic Hydrocarbons

Lectures begin at 8 P. M.

1. Wednesday, September 11.
Destructive Distillation. Fractional Distillation. Coal tar (the ugly duckling of organic chemistry), wood tar; their industrial production and general uses.

2. Wednesday, September 18.
The Genealogic Table of Old King "Coal." Fractionating coal tar. Commercial products—light oil, dead oil, heavy oil, anthracene oil.

3. Wednesday, September 25.
Benzene and its Homologues. Kekulé and his one ring circus. Theories of molecular structure of cyclic hydrocarbons.

4. Wednesday, October 2.
Derivatives of Benzene. Aromatic aldehydes. Alcohols, esters.

5. Wednesday, October 9.
Derivatives of Benzene (Continued). Aromatic acids, benzoic, salicylic, etc.

6. Wednesday, October 16.
Derivatives of Benzene (Concluded). Phenols: Phenol, cresol, resorcinol, pyrogallol.

7. Wednesday, October 23.
Synthetic Medicines from Coal Tar. The fever chasers: Acetanilid, phenacetin, antipyrin.

8. Wednesday, October 30.
Synthetic Medicines from Coal Tar (Concluded). The sleep coaxers and germ killers: Barbital and its compounds. Hexyl-resorcinol. Arsphenamine. Chloramine.

9. Wednesday, November 6.
The Nitrogen Branch of the Coal Tar Family. Anilin—its homologues and derivatives, pyridin and quinolin. Nitrobenzene.

10. Wednesday, November 13.
The Rainbow in a Barrel. Dyes from coal tar. Perkins and his epoch-making mistake. Classification and general uses.

11. Wednesday, November 20.
    Dyes from Coal Tar (Continued). Color and chemical constitution. Coal tar dyes in the textile industries. The new American dyestuffs industry.
12. Wednesday, November 27.
    Dyes from Coal Tar (Continued). Theories of dyeing. The practice of dyeing.
13. Wednesday, December 4.
    Dyes from Coal Tar (Continued). Dyes as indicators and laboratory stains. Dyes in disease. Dyes in the paint and lacquer industry.
14. Wednesday, December 11.
    Dyes from Coal Tar (Concluded). Uses in food-stuffs. Certified dyes. Detection and distinction from natural colors.

ENGINEERING 1

PROFESSOR WAGNER

Materials of Engineering Construction

Lectures begin at 7.45 P. M.*

1. Friday, September 13.
   Properties of Engineering Materials. Force. Stresses. Properties. Testing machines.
2. Friday, September 20.
   Stone. Classification. Composition. Physical properties. Unit stresses.
3. Friday, September 27.
   Brick. Composition. Manufacture. Physical properties. Special uses.
4. Friday, October 4.
   Lime and Cements. Composition and manufacture of lime and its uses. Classification. Manufacture. Physical properties. Tests and uses of cements.
5. Friday, October 11.
   Mortar and Concrete. Sand. Lime mortar. Cement mortar. Grout. Strength. Uses.
6. Friday, October 18.
   Concrete and Mastics. Concrete: proportions, mixing, consistency, placing, and surface finish. Reinforced concrete: strength, uses. Mastics: composition, occurrences in nature, uses.
7. Friday, October 25.
   Wood. The tree. Composition. Cell structure. Classification. Preparation for the market.
8. Friday, November 1.
   Wood (Continued). Seasoning, shrinkage. Durability. Enemies of wood. Preservation processes. Physical properties and unit stresses.
9. Friday, November 8.
   Cast Iron. Ores of iron. Occurrence in nature. Construction of the blast furnace. Metallurgy of the blast furnace. Physical properties and uses.
10. Friday, November 15.
    Wrought Iron. Chemical and physical composition. The puddle furnace. Physical properties. Unit stresses.

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* Please note the hour.

11. Friday, November 22.

    Steel. Definition. Alloys with carbon, nickel and chromium. Processes of manufacture. Recarbonization of wrought iron.

12. Friday, November 29.

    Steel (Continued). Gas producers and their construction. Open hearth process.

13. Friday, December 6.

    Steel (Concluded). Bessemer process and its limitations. Physical properties, strength, and unit stresses of structural steel.

14. Friday, December 13.

    Paints. Corrosion of iron and steel. Composition of paints. Theory and application.

ZOOLOGY 4

PROFESSOR SCHMUCKER

The Laws Underlying Animal Life

Lectures begin at 8 P. M.

1. Monday, January 6.

    The Living Substance. Protoplasm and its properties. The cell. Its structure and multiplication. How cells form tissues.

2. Monday, January 13.

    Mendel and his Peas. Hybrids and their qualities. Dominant and recessive characters. Segregation.

3. Monday, January 20.

    Weismann and his Sheep Ticks. The nucleus and its chromosomes. The machinery of inheritance.

4. Monday, January 27.

    Morgan and his Fruit Flies. Rapid breeding, with many and varied offspring. Mapping the genes.

5. Monday, February 3.

    Forerunners of the Evolution Idea. Early Greek and Latin guesses. The long gap. Milton's fancy. Lamarck and the effects of use.

6. Monday, February 10.

    The Life of Charles Darwin. Early desultory education. His transforming voyage. The Galapagos Islands. "The Origin of Species."

7. Monday, February 17.

    Darwin's "Natural Selection." Too many are born to live. Nature kills off the less fit. The level of animal life slowly rises.

8. Monday, February 24.

    Advances in Evolutionary Theory. Wallace's Geographical Distribution. Wagner's Isolation. DeVries's Mutation.

9. Monday, March 2.

    The Earth as Environment. The effective surroundings. Water as the primitive home. Taking to the land. Man uses all homes.

10. Monday, March 9.

    Adaptation to Surroundings. The necessary fitness. The imperfection of adaptation. Adjustment to changing environment.

11. Monday, March 16.

    Adaptive Radiation. Generalized forms. Their variation in many directions. Parallelism. The renewed struggle.

12. Monday, March 23.
    Heredity and Environment. Their relation. What twins teach us. Heredity decides possibilities, environment decides between them.
13. Monday, March 30.
    Future Evolution. The process is unending. Some animals passed out; others are passing; some lines are very hopeful. How about man?
14. Monday, April 6.
    The Animals and their Family Tree. Linnaeus and his Latin names. Grouping by likeness. True relationship. The Family Tree.

Field Trip

The class in Zoology will be conducted on a field trip under the leadership of Professor Schmucker. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

GEOLOGY 1

PROFESSOR HOWELL

Physical Geography

Lectures begin at 7.45 P. M.*

1. Tuesday, January 7.
   The Earth as a Planet. Its origin, history, form, weight, composition, and movements.
2. Tuesday, January 14.
   The Atmosphere. What it is made of, and why it moves and changes as it does.
3. Tuesday, January 21.
   The Earth's Water Blanket. Fresh waters and salt waters, and their comings and goings.
4. Tuesday, January 28.
   The Earth's Rocky Crust. What it is made of, and why it is always changing.
5. Tuesday, February 4.
   The Interior of the Earth. What we know and can infer about a region we can not see.
6. Tuesday, February 11.
   The Continents and the Ocean Basins. Why the continents ride high and the ocean basins sag, and why each one of them is located where it is.
7. Tuesday, February 18.
   The Shallow Seas, the Cradle of Life. Where the Sun's rays make possible a teeming population of lowly plants and animals.
8. Tuesday, February 25.
   The Depths of the Ocean. The cold, dark world of the deep seas, and its life.
9. Tuesday, March 3.
   The Lowland Fringes of the Continents. The flat borders of the lands, which lie just above sea-level.
10. Tuesday, March 10.
    The High Plains and the Mountain Ranges. The regions of variable climates, and their hardy inhabitants.

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* Please note the hour.

11. Tuesday, March 17.
    Eurasia, the Greatest Continent. Its influence on the evolution of the human race.
12. Tuesday, March 24.
    Africa, the Continent of Contrasts. Where a steaming tropical forest lies between two arid deserts.
13. Tuesday, March 31.
    Australia, Antarctica, and the Islands of the Pacific. The out-of-the-way lands of the Earth.
14. Tuesday, April 7.
    The Americas and the Islands Associated with Them. The lands of the Western Hemisphere, which are now filling up with men.

Field Trip

The class in Geology will be conducted on a field trip under the leadership of Professor Howell. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

PHYSICS 2

PROFESSOR SEELY

Heat and Sound

Lectures begin at 8 P. M.

Heat

1. Wednesday, January 8.
   Heat effects. Heat is vibratory motion in matter. It produces three principal sorts of changes, (a) of temperature; (b) of volume; (c) of molecular arrangement. These changes are interrelated.
2. Wednesday, January 15.
   Temperature is based on the sensation of "hot" and "cold." Sensation is not dependable as a measure of temperature. Thermometers and thermometer scales. The absolute zero.
3. Wednesday, January 22.
   Heat changes often cause changes in volume. Coefficient of linear expansion in solids. Charles' law of gas expansion. Illustrations and application to building, refrigeration, etc.
4. Wednesday, January 29.
   How heat travels through matter and through empty space. Visible and invisible radiations. Measure of heat given off constantly by the sun which is the ultimate source of all of our heat.
5. Wednesday, February 5.
   How actual amounts of heat are measured. The units commonly used are the Calorie and the British Thermal Unit. Heat may be changed into other forms of energy, but always with loss.

No lecture on February 12.

6. Wednesday, February 19.
   Changes in the molecular structure of matter due to heat changes. How heat is involved in freezing, in melting, in vaporizing, and in condensing substances. How these changes vary in different substances. Applications to climate, etc.

7. Wednesday, February 26.

   In engineering the most important changes are those of heat into mechanical energy and thence into electrical energy. The Mechanical Equivalent of Heat. The laws governing these changes.

Sound

8. Wednesday, March 4.

   The relation of a vibrating body to waves in matter. Different sorts of waves are set up. Longitudinal waves and transverse waves.

9. Wednesday, March 11.

   How sound waves cause the sensation of sound. A study of the ear. There are limits to the sense of hearing. The differences between musical sounds and noise.

10. Wednesday, March 18.

    How sound waves travel and their general behavior. Speed, reflection, echoes, whispering galleries. Resonance.

11. Wednesday, March 25.

    Some additional properties of sound waves. Sympathetic vibrations, interference, beats, harmony and discord.

12. Wednesday, April 1.

    Properties of musical sounds—pitch, loudness and timbre. Overtones are the cause of timbre or quality. How musical sounds may be analyzed.

13. Wednesday, April 8.

    Additional study of the physics of music. How scales are made. Melody, harmony and rhythm.

14. Wednesday, April 15.

    A study of two types of musical instruments. The laws of vibrating strings and of air columns; and how the vibrating segments of such bodies produce overtones and thus determine the timbre or quality of the note.

MUSEUM TALKS

Monday evenings at 7 o'clock

This series comprises informal talks, given on Monday evenings in the Museum, illustrated by specimens.

Professor Howell

Minerals, Rocks, and Fossils

Sept. 9.	Minerals, the Components of Rocks.
Sept. 16.	Rocks Which Were Laid Down Layer Upon Layer.
Sept. 23.	Rocks Which Were Once Hot.
Sept. 30.	The Fossils in the Rocks—Plant Fossils.
Oct. 7.	Fossils of Invertebrate Animals.
Oct. 14.	Fossil Vertebrates and Prehistoric Human Bones and Implements.

Professor Schmucker

Animals of the Water

Oct. 21.	Water as a Home.
Oct. 28.	Microscopic Animals.
Nov. 4.	Oysters and Clams.
Nov. 11.	Crabs and Lobsters.
Nov. 18.	Whales and Porpoises.
Nov. 25.	The Life of the Shad.

Miss Borden

Animals of the Land

Dec. 2.	Animals That Live Underground.
Dec. 9.	Animals That Prowl About at Night.
Dec. 16.	Animals That Live in Herds.
Dec. 23.	No Lecture.
Dec. 30.	No Lecture.
Jan. 6.	Feathered Animals That do not Fly.
Jan. 13.	Strange Animals That Live in Hot Countries.
Jan. 20.	Animals Nearest to Man.

Mr. Lawrence

Animals of the Air

Jan. 27.	Adaptations for Aerial Life.
Feb. 3.	Feathered Globe Trotters.
Feb. 10.	Flights for Food.
Feb. 17.	The Love Flights of Insects.
Feb. 24.	Night Fliers.
Mar. 2.	Man's Aerial Enemies and Friends.

Professor Kaiser

Great Groups of Plants

Mar. 9.	Liverworts and Mosses. Their Life Histories and Place in Nature.
Mar. 16.	True Mosses. Their Structure, Classification, Kinds and Uses.
Mar. 23.	Ferns. Their Life History, Structure and Classification.
Mar. 30.	Ferns. Their Kinds, Uses, Beauty and Culture.
Apr. 6.	Fern Allies. Water Ferns, Horsetails, Club Mosses and Quillworts.
Apr. 13.	Gymnosperms. Cycads, Gnetaceae. Yews and the Great Pine Family.

GENERAL SCHEDULE OF REGULAR LECTURES

Subjects of courses in each of the four successive years constituting a full term.

ENGINEERING

1. Materials of Engineering Construction.
2. Civil Engineering Structures.
3. Roads, Railroads and Tunnels.
4. Water Supply, Sewers, Canals, Rivers and Harbors.

PHYSICS

1. Properties of Matter. Mechanics.
2. Heat and Sound.
3. Light.
4. Electricity and Magnetism.

INORGANIC CHEMISTRY

1. General Principles, Notation, Nomenclature.
2. Descriptive Chemistry.
3. Descriptive Chemistry.
4. Descriptive Chemistry.

ORGANIC CHEMISTRY

1. General Principles, Aliphatic Hydrocarbons.
2. Carbohydrates, Fats, Oils and Waxes.
3. Cyclic Hydrocarbons.
4. Compounds of Nitrogen.

ZOOLOGY

1. Invertebrate Animals.
2. Vertebrate Animals.
3. Human Biology.
4. Principles of Animal Life.

BOTANY

1. Morphology.
2. Taxonomy.
3. Taxonomy (continued).
4. Physiology and Ecology.

GEOLOGY AND PALEONTOLOGY

1. Physical Geography.
2. Physical Geology.
3. Paleontology.
4. Historical Geology.

LECTURES UNDER RICHARD B. WESTBROOK FOUNDATION

1912.—Ancient Civilization of Babylonia and Assyria. *Morris Jastrow, Jr., Ph.D.*
1913.—Conservation of Natural Resources. *Gifford Pinchot, Marshall O. Leighton, Overton W. Price, Joseph A. Holmes.*
1914.—The Theory of Evolution. *William Berryman Scott, Ph.D., LL.D.*
1915.—Invisible Light. *Robert Williams Wood, LL.D.*
1916.—Aspects of Modern Astronomy. *John Anthony Miller, A.B., A.M., Ph.D.*
1917.—Heredity and Evolution in the Simplest Organisms. *H. S. Jennings, B.S., A.M., Ph.D., LL.D.*
1918.—The Chemistry, Nutritive Value and Economy of Foods. *Harvey W. Wiley, A.M., M.D., B.S., Ph.D., LL.D., D.Sc.*
1919.—The Origin and Antiquity of the American Indian. *Aleš Hrdlička, M.D., Sc.D.*
1920.—Chemistry and Civilization. *Allerton S. Cushman, B.S., A.M., Ph.D.*
1921.—Microbiology. *Joseph McFarland, M.D., Sc.D.*
1922.—Evolution of the Human Face. *William K. Gregory, Ph.D.*
1923.—The Philosophy of Sanitation. *George C. Whipple, B.S.*
1924.—The Distribution of American Indian Traits. *Clark Wissler, A.M., Ph.D.*
1925.—Structural Colors. *Wilder D. Bancroft, Ph.D., Sc.D.*
1926.—The Animal Mind; its sources and evolution. *George Howard Parker, Sc.D.*
1927.—An Interpretation of Atlantic Coast Scenery. *Douglas W. Johnson, Ph.D.*
1928.—The Science of Musical Sounds. *Dayton C. Miller, Ph.D.*
1929.—Volcanoes and Vulcanism. *William B. Scott, Ph.D., LL.D.*
1930.—Present Problems of Evolution. *Edwin Grant Conklin, Ph.D., ScD., LL.D.*
1931.—The Problems of the Origin and Antiquity of the American Aborigines in the Light of Recent Explorations. *Aleš Hrdlička, M.D., Sc.D.*
1932.—Common Sense, Science and Philosophy. *John Dewey, Ph.D., LL.D.*
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Republication of Conrad's Fossils of the Medial Tertiary of the United States. Introduction by *William H. Dall.* (Out of Print.)

BULLETIN
of the
WAGNER FREE INSTITUTE OF SCIENCE
PUBLISHED BY THE INSTITUTE
SYDNEY L. WRIGHT, *Editor*

Vol. 10 Quarterly $1.00 per year
No. 4 November, 1935

A NEW PARADOXIDES FROM THE CAMBRIAN OF NEW BRUNSWICK

By BENJAMIN F. HOWELL, A.M., PH.D.

The most abundant and characteristic fossils of the Middle Cambrian rocks of northeastern North America, Europe, and northwestern Africa are trilobites of the genus *Paradoxides*. The many species of this genus are so useful as index fossils in these rocks that a number of them have been chosen as the name fossils for the Middle Cambrian zones of those parts of the world. For this reason, and because they are large and conspicuous trilobites—a few being among the largest known representatives of this group of crustaceans—these denizens of those ancient seas have a peculiar fascination for students of Cambrian faunas, and the discovery of a new species of *Paradoxides* is of more than ordinary interest. The finding of a new form in the classic Cambrian region of southeastern New Brunswick therefore seems worthy of special record.

PARADOXIDES MATTHEWI, NEW SPECIES

Cranidium. Broad in proportion to its length, with a widely expanded glabella that is very bluntly rounded in front. Brim very narrow in front of the glabella, but of normal width at the sides. Palpebral lobes very wide and long, extending from a point close to the glabella back to the rear border. Neck furrow well developed. Two other furrows completely crossing the glabella. There are no clear traces of any other glabellar furrows, but very faint indications of two very incomplete ones can be seen on some cranidia. The convexity is average for a *Paradoxides*. The test is smooth.

Free cheeks. Border wide. Spine rather long, slightly curved, and gently tapering, ending in a very acute point.

Hypostome. Known only from fragmentary examples, the best one of which is figured.

Thorax. Known only from fragments, which indicate that the pleura were long, narrow, evenly curved, and finely pointed.

Pygidium. Known only from a single fragmentary example, of which only the anterior half is preserved. This has a tapering axis of 4 segments. The whole pygidium was probably rather small and narrow.

This species is named in honor of Dr. G. F. Matthew, whose work made southeastern New Brunswick classic ground for the student of Cambrian paleontology.

Location of types. The holotype is no. 42015a in the paleontological collection of Princeton University. Paratypes are nos. 41762, 42015b, and 42016–42024 in the same collection.

Horizon and locality. In limestone nodules holding *Triplagnostus lomondensis*, found in black shale of Late Paradoxidian Cambrian age, beside the road along the southeastern shore of Loch Lomond, southeastern New Brunswick, Canada.

Comparisons with other species. Paradoxides matthewi belongs to that group of species which are characterized by their relatively wide and blunt glabellas, and whose best known species are *Paradoxides tessini*, of Scandinavia, and *Paradoxides abenacus*, of New Brunswick and Newfoundland. These species range through the middle third of the *Paradoxides* Beds of Europe and North America.

P. matthewi differs from *P. tessini* in having longer palpebral lobes and a glabella that is more bluntly rounded in front. It differs from *P. abenacus* in the same way. It also grew larger than *tessini* or *abenacus*. It was probably very similar to the form which Dr. Matthew described as *Paradoxides abenacus* mut.*, which occurs in beds holding *Goniagnostus nathorsti* at Hastings Cove, New Brunswick. It may be identical with that form, and be properly classified as a variety of *abenacus;* but Matthew's "*abenacus* mut." is known only from fragments, and *matthewi* is still to imperfectly known to enable us to be certain of its exact relationships.

One of the paratypes of *P. matthewi* which is figured here is a young cranidium. The glabella of this individual is not so bluntly rounded in front as are the glabellas of larger specimens. In this character the young cranidium more resembles the cranidia of *P. tessini*, *P. abenacus*, and even of some of the species characteristic of the older *Paradoxides* Beds, such as *P. eteminicus*. It is possible that this specimen is not properly referred to *P. matthewi;* but it seems likely that it is, for another, somewhat larger paratype cranidium, which is also figured, appears to be intermediate between the younger one and the adult cranidia of *matthewi*. This intermediate cranidium much resembles a cranidium of *P. tessini*.

The cranidium of the English trilobite described by Dr. E. S. Cobbold as *Paradoxides bohemicus salopiensis* greatly resembles that of *P. matthewi*, but the pygidium which Dr. Cobbold assigns to his form is different from that here assigned to *P. matthewi*, and *salopiensis*, too, seems not to have grown so large. *P. bohemicus salopiensis* must have had a time range not greatly different from that of *P. matthewi*, however, and may be the English cousin of the New Brunswick species.

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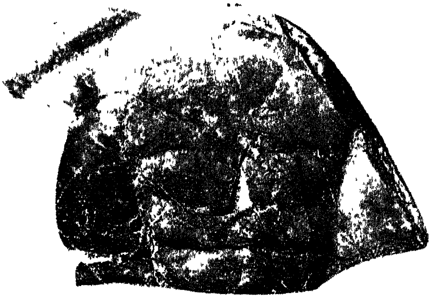
* Trans. Roy. Soc. Canada, 2nd ser., vol. 3, sect. 4, 1897, p. 175, pl. 1, f. 9a.

Fig. 1: *Paradoxides matthewi*, new species. The holotype cranidium.

Figs. 2–8: The same species. Paratype cranidia, free cheeks, thoracic segments, and pygidium.

All the figures are natural size.



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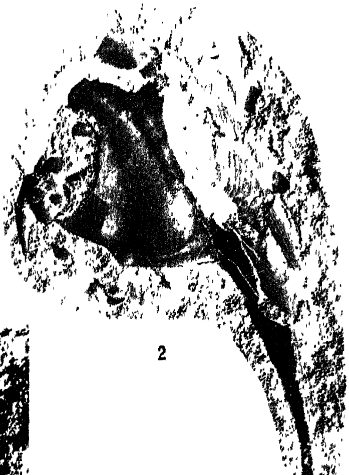

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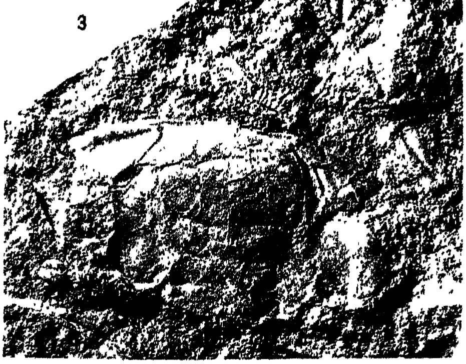

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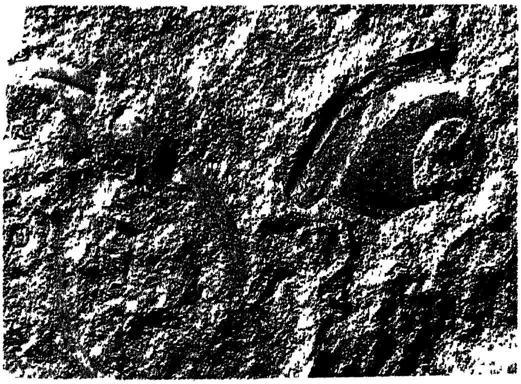

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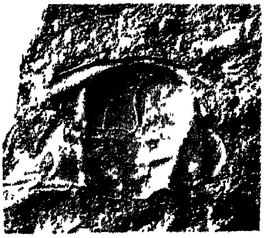

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BULLETIN
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MUSEUM EXHIBITION OF ROCK SECTIONS

The Museum exhibition of thin sections of rocks has always been a problem for curators.

At the suggestion of Dr. B. F. Howell, Professor of Geology and Palaeontology at the Institute, the apparatus described in this paper was designed and made by Mr. William Van Horn. The rock sections were prepared and mounted by Mr. Harold Poole. It was through the persistence and ingenuity of these two men that the instrument was brought to its present form. Considerable experimenting was required and the instrument was rebuilt several times before a satisfactory model was obtained.

Designed primarily for Museum purposes, the apparatus may be used also for class-room instruction. It forms a compact unit which, when unbolted from its stand, may readily be carried from room to room.

The apparatus consists essentially of a petrographic microscope mounted in relation to a vertical spindle carrying two discs at right angles to the axis of the spindle. The upper disc (*a*) contains eight small specimens of rocks which are viewed through a window at the top of the machine.

The lower disc (*b*), described as the slide carriage, is divided into eight parts bearing the mounted rock sections. This disc revolves directly over the stage of the microscope under the objective. The spindle (*c*) on which these discs are mounted is rotated by bevel gears connected with a shaft at right angles which projects through the right side of the case and is turned by means of a knob (*d*).

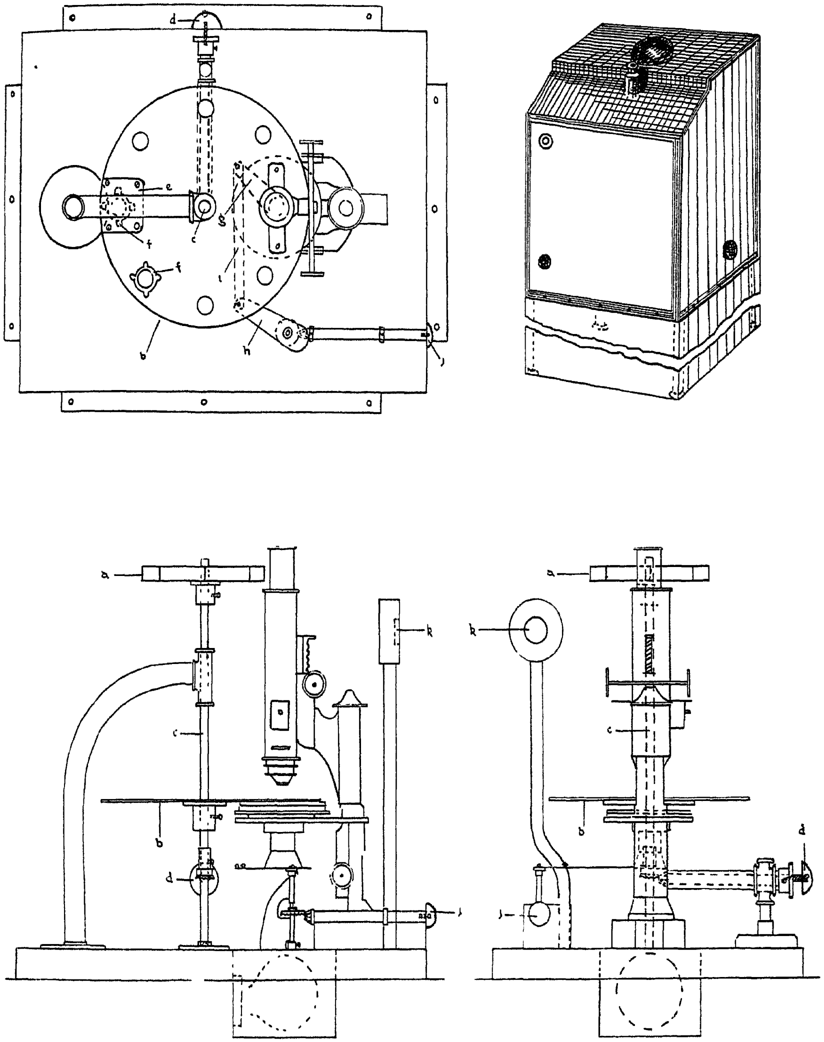
The principal problem which presented itself at the outset was the difficulty of maintaining a focus on each section as it revolved under the objective without the necessity of changing the adjustment of the microscope. This was neatly overcome by mounting the slides between metal plates (*e*) and phosphor-bronze spring clips (*f*) with four feet bent at angles. The tension of these springs was regulated by tightening or loosening four knurled nuts, the exact procedure being as follows: One section was placed on the carriage over the spring clip and brought into focus by manipulation of the coarse and fine adjustments of the microscope in the ordinary manner.

The next section was then brought into position under the objective and focused by changing the tension of the phosphor-bronze spring clip, which raised or lowered the slide until a perfect focus was obtained. In a similar manner the other six sections were brought into focus. As the section comes into position under the objective it is viewed through the eyepiece of the microscope, and the rock itself from which the section was made may also be viewed through the window in the top of the case. Thus rock and section may be studied macroscopically and microscopically at the same time.

As an additional feature it was thought desirable to permit the observer to rotate the polarizer of the microscope and see the result. This was accomplished by placing a ring around the polarizer, which in turn was connected to levers *g*, *h*, and bar *i*. This system is operated by gears similar to those rotating the slide carriage, and a knob (*j*).

Lighting is direct and supplied by a 25-watt lamp housed in a metal case below the base of the microscope. A momentary contact switch (*k*) controls the circuit and is operated by an auxiliary push button on the front of the case. Thus the machine is illuminated only when the observer pushes the button.

The entire apparatus is enclosed in a dust-proof case. A metal tube which is part of the case fits closely over the draw-tube of the microscope. At its upper end is a thin disc of optical glass through which the image is observed and which also serves to protect the eyepiece.



APPARATUS FOR EXHIBITION OF ROCK SECTIONS

a, Specimen carriage.
b, Slide carriage.
c, Spindle.
d, Knob for revolving slide carriage.
e, Plate covering slide and spring.
f, Phosphor-bronze spring.
g-*h*-*i*, Levers and bar to rotate polarizer.
j, Knob to turn polarizer.
k, Momentary contact switch.

HINTS ON MUSEUM TECHNIQUE

JOHN G. HOPE

Preparator, Wagner Free Institute of Science

A SIMPLE DEVICE FOR THE ACCESSORY WORKER

While engaged in making models of the Skunk-cabbage for a habitat group the need was felt for a device which would soften the wax at any point, leaving the remainder firm, and not affect the definition of the wax cast. The device described below was found to be satisfactory.

An ordinary Florence flask such as is used in a chemical laboratory was fitted with a rubber stopper. Through the single hole in the stopper was fitted a connecting bulb of the type used in the Kjeldahl apparatus for the determination of nitrogen. This was used to trap any hot water which might otherwise be forcibly ejected onto the wax, causing damage. A piece of flexible rubber tubing was slipped over the other tube of the bulb.

Nozzles were made by drawing out glass tubing in a bunsen flame. Depending upon the rate of speed at which the glass was drawn, fine or coarse orifices could be obtained. By heating back of the drawn portion and bending it a very useful curved nozzle was obtained.

In assembling the spathe of the Skunk-cabbage, the flask was partly filled with water and heated over the bunsen flame. One of the nozzles was then inserted in the free end of the rubber tubing.

The stem sections of the spathe were welded together with a hot tool, and then, by directing steam from the nozzle, any portion of the section could be softened and bent to the desired curve.

The rubber hose and nozzle became very hot and it was found expedient to pass the glass nozzle through a cork to protect the fingers. A clip was devised to hold the nozzle and tubing when not in use in the hand.

Care must be taken not to allow the steam to play on the same spot too long, or a hole in the wax will result. However, with careful use, the device proved very helpful in welding and shaping the sections.

AN EFFECTIVE MUSEUM LABEL

In relabeling and rearranging the palaeontological collection, it was felt that the Era and Period labels should be strikingly different from the other labels used in the collection. All metal labels, using aluminum or chromium letters on a copper background would have been excellent but expensive, and the following cheap and easily made label was found to be an excellent substitute.

A piece of "Plywood" of the required size was coated on one side with glue and covered with a metallic gold paper of good quality. The letters were formed of "bus wire," a tinned copper wire of radio fame. The wire being soft, the letters can be shaped easily with a pair of round-nosed pliers. The letters were cemented to the background with DuPont's cement.

The resulting label presented an excellent appearance.

BULLETIN

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HARTTITES, NEW NAME FOR HARTTIA WALCOTT, PREOCCUPIED

B. F. HOWELL AND J. B. KNIGHT

Abstract

Harttites is proposed as a new name for the Middle Cambrian genus to which C. D. Walcott in 1884 gave the name *Harttia*, now found to have been proposed by Steindachner in 1877 for a genus of fishes. Walcott assigned his genus to the Gastropoda, but the correctness of this assignment is questioned, and the affinities of the genus are considered to be as yet undetermined.

In 1884 Walcott[1] proposed the name *Harttia* for a new species, *H. matthewi*, based on a single little shell from the Middle Cambrian *Paradoxides* beds of New Brunswick which he thought to be a gastropod. This name had, however, been used seven years earlier by Franz Steindachner[2] for a genus of teleostean fishes inhabiting the freshwater streams of southeastern Brazil. The new name, *Harttites*, is therefore here proposed for Walcott's genus.

Through the courtesy of Professor Gilbert D. Harris, of Cornell University, we have had the privilege of studying the holotype of "*Harttia matthewi*" Walcott, 1884 (loc. cit., p. 19), the only known specimen of the only known species of the genus. The fossil is an impression in a piece of fine grained slate-gray shale from St. John, New Brunswick, which also carries numerous other fossils typical of the *Paradoxides eteminicus* fauna. None of the original organic material of any of the fossils is preserved, nor is any of it replaced.

---

[1] Walcott, C. D., On the Cambrian faunas of North America: U. S. Geol. Surv., Bull., no. 10, p. 18–19, 1884.

[2] Steindachner, Franz, Die Süsswasserfische des südöstlichen Brasilien (III): Kaiserl. Akad. d. Wissensch., Sitzungsber. d. Math.-Naturwis. Cl., Bd. 74, Abt. I, p. 668–669, Vienna, 1877.

Walcott's figure of 1884 (loc. cit., pl. 1, fig. 3), supplemented by Matthew's of 1886,[1] have given rise to the fiction that we have in this specimen the actual shell parts of this most obscure organism. Though Walcott in his description remarks that the specimen is in the form of a cast, which remark is repeated by Matthew, his detailed description of the supposed morphology of the organism makes it apparent that he misinterpreted details of the cast as being shell material, presumably replaced. As a matter of fact, the specimen is the external mold of a part of some organism of unknown affinities. The counterpart of the mold is missing. The edges of the impression seem to have been determined by fracture and do not necessarily define the edge of a shell. The features described by Walcott as an internal subcordate shield-like expansion, supported by a low, broad, median ridge, are actually rendered in matrix, though it is easy to be deceived by a fancied resemblance to the internal platform of the Calyptraeidae into interpreting it, as Walcott did, as a shell structure, or replaced shell structure. Inasmuch as every detail of the specimen is rendered in matrix, and not in altered or replaced organic material, it is necessary to revise the interpretation of the organism presented by Walcott in the light of this fact. A further consideration is that the impression has been somewhat affected by tooling. The broadened end of the median ridge in the impression (a groove in the part that made the impression), where the ridge seems to blend with the "shield-like expansion," has been considerably worked on with a tool, presumably by Hartt, Matthew, or Walcott. Exactly what its original form was cannot be determined on the specimen. There is no evidence for the dormer-like triangular area shown in Walcott's figure nor the modifications of it shown in Matthew's.

Describing the organism, or part of an organism (that it was indeed organic is hardly open to doubt), that made the impression preserved to us, we find that it is probably broadly oval in outline and bilaterally symmetrical. It is strongly convex from side to side, more gently so from end to end. The upper surface is markedly flattened, with a sharply defined sub-cardiform depression occupying one end of the upper surface, the broadly rounded "point" of the area close to one end and the two narrowly rounded "barbs" extending about halfway to the other. Just outside the rounded tip of each barb is a rather sharp, spine-like projection, which blends gradually with the obscure margins of the flattened area. Within the flattened area is a median groove that seemingly connects with the cardiform depression, though the exact relations are obscured by the above mentioned tooling of the impression.

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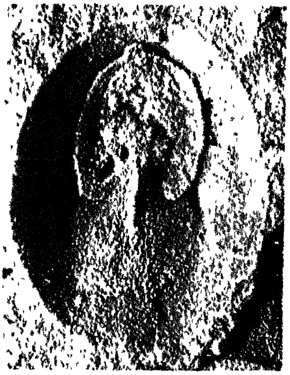
[1] Matthew, G. F., Illustrations of the fauna of the St. John group continued: Royal Society of Canada, Trans. vol. 3, sec. 4, pl. 5, fig. 10, Montreal, 1886.

One of the authors of this paper (Howell) is a student of Cambrian life, the other (Knight) is a student of Paleozoic gastropoda. We are both wholly at a loss to recognize the systematic position of this organism. We feel that Walcott's conclusion that it is a gastropod is unwarranted and was based on a misinterpretation of matrix as being shell or replaced shell. We will welcome suggestions that will help to solve the problem of the nature of this curious bit of Cambrian life.

EXPLANATION OF PLATE

Harttites matthewi (Walcott). A photograph of the holotype, × 15.

1 and 2. Two prints from the same negative, differently oriented. The eye refuses to accept these two prints as being identical in all particulars except orientation, and hence one of them will appear to the viewer as a cast of the other. The one that appears convex is thus a representation of external form of the organism, or part of an organism, that formed the impression. Note how strongly the sub-cardiform depression in the top of the convex organism suggests a scar of attachment. The two deep holes on the left-hand side of the mold of the sub-cardiform depression in figure 1 are deep tool marks. The tool marks on the broad upper end of the mold of the median groove are not so sharp and cannot be distinguished in the photograph as they can on the specimen, though the rough, irregular depression just above is artificial.



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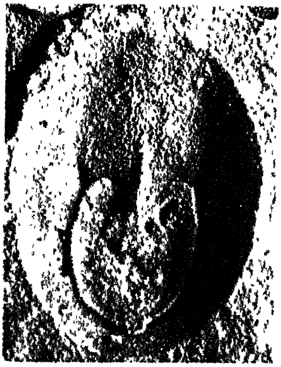

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THE WAGNER FREE INSTITUTE OF SCIENCE

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HISTORY

The Wagner Free Institute of Science was founded in 1847 by William Wagner, a citizen of Philadelphia.

In his early life William Wagner became associated with Stephen Girard in the extension of Girard's mercantile business. While in Girard's employ he had the opportunity to visit foreign countries, and being interested in scientific pursuits, he made a study of scientific institutions abroad and collected natural history specimens which afterward formed the nucleus for the collections in the museum of the Institute.

The Institute, itself, had its inception in a series of free lectures delivered by Professor Wagner in his home. These lectures, begun in 1847, were continued until 1855 when the Institute was incorporated by act of legislature.

A large measure of credit is due Mrs. Louisa Binney Wagner, Professor Wagner's wife, for sympathy, understanding and active coöperation in the early days of the founding of the Institute.

In 1855 a faculty was appointed and the work was continued in a new location at 13th and Spring Garden Streets, the City of Philadelphia giving permission for the use of Commissioners' Hall. Some years later Professor Wagner decided to erect a building on the present site at Seventeenth Street and Montgomery Avenue. This building was completed in 1865 and occupied immediately.

William Wagner died in 1885 and the management of the Institute was transferred to a Board of Trustees.

In 1901 a wing was added to the building for the use of a branch of the Free Library of Philadelphia.

INSTRUCTION

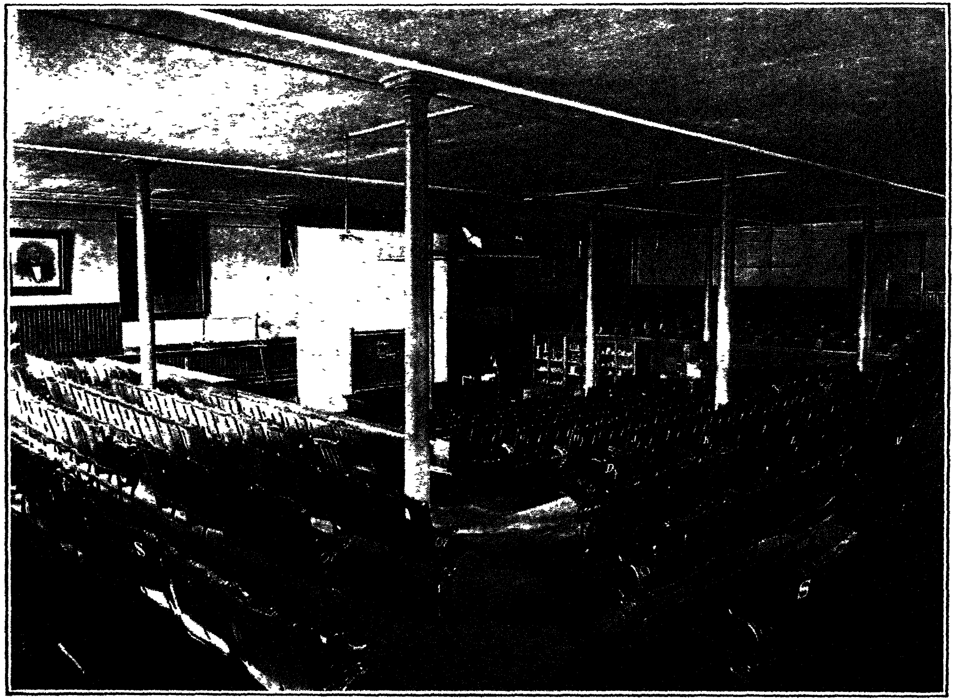
LECTURES AND CLASS-WORK

Instruction at the Wagner Free Institute of Science is conducted by means of lectures supplemented by class work. There are no tuition fees.

Persons may attend lectures without registering for the classes if they so desire. Those registering for the classes are required to hand in a weekly paper and are admitted to an examination at the end of the term. Those persons successfully passing the examination are awarded certificates for the year's work.

There are seven courses of scientific lectures covering a period of fourteen weeks each for four years. On the successful completion of four years' work a Full Term Certificate is awarded.

The closing of each lecture season is marked by Commencement Exercises.



Auditorium

MUSEUM

MUSEUM

The Institute maintains a natural history museum containing more than 21,000 specimens illustrating the various branches of natural science.

The collections are arranged especially for study. The museum is open to visitors on Wednesday and Saturday afternoons from 2 P.M. until 5 P.M., except legal holidays.

On each Monday evening at 7 P.M., from September to May, a "Museum Talk" is delivered in the museum, the speaker using the specimens in the museum to illustrate the lecture.

Teachers and students desiring to use the museum for special studies will be admitted upon application at the office.

LIBRARIES

The Reference Library of the Institute contains over 25,000 bound volumes and approximately 150,000 pamphlets on scientific subjects, classified and arranged for ready reference. There are also many foreign and domestic periodicals on file. The library is open to the public as well as to students from 10 A.M. to 9 P.M. daily, except Sunday.

The Free Library of Philadelphia maintains a branch library in the building, known as the Wagner Institute Branch, from which books may be taken out under the rules of the Free Library.

PUBLICATIONS

The publications of the Institute consist of three series:

Transactions: begun in 1885 and discontinued in 1927.

Publications: succeeding the Transactions. These Publications are issued at irregular intervals.

Bulletin: issued quarterly.

SPECIAL LECTURES

WESTBROOK FREE LECTURESHIP

The Westbrook Free Lectureship is supported by the income from an endowment provided by Dr. Richard Brodhead Westbrook and his wife, Dr. Henrietta Payne Westbrook. The lectureship was established in 1912 and provides for one course of lectures each year. These lectures cover a wide range of topics and a list of those so far given may be found on page 27.

FANNIE FRANK LEFFMANN MEMORIAL LECTURESHIP

The income of a fund given by Dr. Henry Leffmann is applied to occasional special lectures under the Memorial Lectureship. These lectures are popular in character.

The *Philadelphia Natural History Society* is affiliated with the Institute and holds meetings on the third Thursday of each month from October to May.

RESEARCH

The Institute has carried on research work since 1885 in various departments of science. Results of research have been published from time to time in the Transactions, Publications and Bulletin.

The Institute is also the recipient of the income from two funds established by Dr. Henry Leffmann. This income is devoted to research in chemistry.

CERTIFICATES AWARDED AT CLOSING EXERCISES, MAY 13, 1936

FULL TERM CERTIFICATES

BOTANY

R. Edythe Green
Albert J. Rosenheimer

ORGANIC CHEMISTRY

Burton J. Cherney
R. Edythe Green
John C. R. Hofferbert
John G. Hope
Dorothy G. Lloyd
H. J. Magnin
Albert J. Rosenheimer

ENGINEERING

Jack Dunn

PHYSICS

Burton J. Cherney
R. Edythe Green
John W. Quinn
Albert J. Rosenheimer

INORGANIC CHEMISTRY

Burton J. Cherney
William D. S. Gillette
R. Edythe Green
John J. Kane
H. J. Magnin
Reba A. G. Mimms
Albert J. Rosenheimer

ZOOLOGY

Francis E. Fink
H. L. Grabosky
R. Edythe Green
John W. Quinn
Albert J. Rosenheimer
Sylvia B. Young

GEOLOGY

R. Edythe Green
Albert J. Rosenheimer
Sylvia B. Young

1935-1936 CERTIFICATES

BOTANY 1

Arthur S. Adams
Ina Bein
John Berninger
Myles Brazill
Adon E. Burnham
Myra G. Cassel
Robert J. Crawford
John Dornan
Francis H. Doyle
Helen G. Durner
Beecher Finch
Nathan Fitelson
Eva M. Frank
Edward P. Frey
Oscar F. E. Gentieu
Mrs. Joseph E. Gibbons
Florence H. Gillin
James R. Gillin
George Gordon
Marie E. Gordon
H. L. Grabosky
R. Edythe Green
Eileen E. Hand
Louis E. Hand
John C. R. Hofferbert
Frank P. Ingenito
John J. Kane
Fannie S. Kirshner
George A. Leucht
Harriet A. Lyon
William Mahn
Dorothy S. Miller
Joseph J. Mullin
Lilla P. Murdoch
Lola I. Poppleton
William G. Ramsey
Edith G. Rice
Albert J. Rosenheimer
Nancy M. Smith
Charles F. Summers
Helen B. Vail
George F. Werner

INORGANIC CHEMISTRY 3

John Berninger
Myles Brazill
Burton J. Cherney
John W. Dalgarn
Roscoe A. Davis
John M. Finn
Joseph Fisher
Ludwig Frank, Jr.
William D. S. Gillette
R. Edythe Green
Ralph A. Hafner
Thomas H. Hart
John J. Kane
William J. Keighley
Virginia A. Lang
H. J. Magnin
Reba A. G. Mimms
Louis Moyd
Joseph J. Mullin
Frederick A. Nixon
Donald O'Keefe
Peace Paubionsky
William G. Ramsey
Albert J. Rosenheimer
William Schlesman
Anthony J. Schubert
Milton R. Sheen
Rudolph B. Smith, Jr.
Charles F. Summers
Joseph Sussna
David Travis
G. Willard Webster
James R. Wescott
Thomas Willis, Jr.

ORGANIC CHEMISTRY 3

John Berninger
William J. Boegley
Myles Brazill
Burton J. Cherney
Roscoe A. Davis
Elizabeth T. Ewing
John M. Finn
Joseph Fisher
Edward H. Gillette
R. Edythe Green
Spencer A. Griffin
Ralph A. Hafner
John F. Hardecker
Thomas H. Hart
John C. R. Hofferbert
John G. Hope
Margaret L. Hubbard
Harold H. Jones
Virginia A. Lang
Dorothy G. Lloyd
Norris V. McCool
H. J. Magnin
Charles W. Mayer
Seymour Moses
Joseph J. Mullin
Frederick A. Nixon
William G. Ramsey
Albert J. Rosenheimer
William Schlesman
Otto J. Schoppe
Anthony J. Schubert
Milton R. Sheen
Clifford S. Shipley
Rudolph B. Smith, Jr.
George F. Stauffer
Harry J. Stratton
Charles F. Summers
David Travis
John H. Warnick
G. Willard Webster
Thomas Willis, Jr.

ENGINEERING 1

Gus A. Bacharach
John Berninger
William Brody
Roscoe A. Davis
Bernard Dunn
Jack Dunn
Beecher Finch
Joseph Fisher
Edward Freedman
Grant A. Garman
Oscar F. E. Gentieu
Ralph A. Hafner
Elmer S. Jenkins
Peter P. John
Willard C. Jones
Eugene F. Lennon
Thomas Lennon
John F. McDevitt
James F. Mahoney
Joseph J. Mullin
Charles J. Peyton
Edward N. Sibre
Francis Sibre
Homer J. Stineman
Charles F. Summers
Arthur T. Tigue
William A. Tresca
Henry R. Welsford
George F. Werner
Thomas Willis, Jr.

ZOOLOGY 4

Arthur S. Adams
Ina Bein
John Berninger
Myles Brazill
Norman P. Breyer
Robert J. Crawford
Roscoe A. Davis
Francis H. Doyle
Beecher Finch
Martha L. Finch
Francis E. Fink
Nathan Fitelson
Willis George
Elinor A. Glackin
H. L. Grabosky
R. Edythe Green
Gordon Hill
John G. Hope
Harold Jones
William Mahn
Blanche Manning
Caroll R. McDonnell
Joseph J. Mullin
John W. Quinn
William G. Ramsey
Albert J. Rosenheimer
Evelyn C. Sampson
William A. Saylor
George F. Stauffer
Lelia M. Stauffer
Thomas L. Strong
Charles F. Summers
William Thompson
David Travis
Helen B. Vail
Sylvia B. Young

GEOLOGY 1

John Berninger
Roscoe A. Davis
Beecher Finch
Nathan Fitelson
R. Edythe Green
Arthur B. Guest
Ralph A. Hafner
John F. Hardecker
Blanche Manning
Louis Moyd
Joseph J. Mullin
William G. Ramsey
Albert J. Rosenheimer
Charles F. Summers
David Travis
Helen B. Vail
David B. Walker
Sylvia B. Young

PHYSICS 2

John Berninger
Myles Brazill
Burton J. Cherney
Roscoe A. Davis
Francis H. Doyle
Beecher Finch
Joseph W. Fisher
R. Edythe Green
Ralph A. Hafner
Thomas H. Hart
Virginia A. Lang
Edward S. McGhee
Louis Moyd
Joseph J. Mullin
Peace Paubionsky
John W. Quinn
William G. Ramsey
Albert J. Rosenheimer
Edward W. Sanders
Max Sigmund
Charles F. Summers
David Travis

FACULTY

SAMUEL CHRISTIAN SCHMUCKER

A.M., M.S., Sc.D., Muhlenberg College.
Ph.D., University of Pennsylvania.
Professor of Biological Sciences, State Teachers College, West Chester, Pa., 1895–1923.
Science Department, Summer Schools, Chautauqua, N. Y., 1906–1928.
Lecturer on Biology, Brooklyn Institute of Arts and Sciences, 1905–1933.
Professor of Botany, Wagner Free Institute of Science, 1908–1926.
Professor of Zoology, Wagner Free Institute of Science, 1926 to date.
Dean of the Faculty.
Author of
- "The Study of Nature." (Lippincott Co., Philadelphia.)
- "The Meaning of Evolution." (Macmillan Co., N. Y.)
- "Man's Life on Earth." (Macmillan Co., N. Y.)
- "Heredity and Parenthood." (Macmillan Co., N. Y.)

JOHN WAGNER, JR.

B.S. in C.E. 1913, University of Pennsylvania.
C.E. 1920, University of Pennsylvania.
Assoc. M., Am. Soc. C. E.
1913–1916, Draftsman, Phoenix Bridge Company.
1916–1921, Office of Engineering Bridges and Buildings, Pennsylvania Railroad, including two years' service with the Army as First Lieut. and Captain in the Cavalry.
1921–1926, Assistant Supervisor Track, Reading Company.
1926–1928, Supervisor Track, Reading Company.
1928 to date, Industrial Agent, Reading Company.
Professor of Engineering, Wagner Free Institute of Science, 1926 to date.

LESLIE BIRCHARD SEELY

Graduate, State Normal School, Bloomsburg, Pa.
Taught school, Luzerne and Snyder Counties, Pa.
Assistant instructor in physics and chemistry, Bloomsburg, 1899–1902.
Graduate, Haverford College, 1905.
Head Master, Friends Institute, Chappaqua, N. Y., 1905.
Instructor in physics, Northeast High School, Philadelphia, 1906–1915.
Head of Science Department, Germantown High School, 1915–1923.
Principal, Roxborough High School, 1923–1924.
Principal, Germantown High School, 1924 to date.
Graduate courses, University of Pennsylvania and Brooklyn Institute, 1906–1910.
Honorary degree of Doctor of Pedagogy, Ursinus College, 1926.
Professor of Physics, Wagner Free Institute of Science, 1912 to date.
Publications:
- "Description of Two New Distomes," Biological Bulletin, Lancaster, Pa., 1906.
- "Ether Waves and the Messages They Bring," Transactions of the Wagner Free Institute of Science.
- "The Physics of the Three-electrode Bulb," Transactions of the Wagner Free Institute of Science.

DAVID WILBUR HORN

A.B., Dickinson College, 1897.
A.M., Dickinson College, 1898.
Ph.D., Johns Hopkins University, 1900.
Assistant in Chemistry, Johns Hopkins University, 1900–1901.
Associate and Associate Professor of Chemistry, Bryn Mawr College, 1901–1907.
Lecturer in Hygiene, Hahnemann Medical College, 1911 to date.
Head of Pre-Medical School of Science, Hahnemann Medical College, 1916–1921.
Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science, 1921 to date.
Professor of Inorganic and Physical Chemistry, Wagner Free Institute of Science, 1911 to date.

Chairman of Philadelphia Section of American Chemical Society, 1904 and 1905.
Fellow of American Association for the Advancement of Science.
Fellow of the Royal Society of Arts of London.

IVOR GRIFFITH

Early education at the Bethesda Academy, Wales, and came to America in 1907.
P.D., Philadelphia College of Pharmacy and Science, 1912.
Ph.M., Philadelphia College of Pharmacy and Science, 1921.
Sc.D. (Hon.), Bucknell, 1934.
Director of Research, John B. Stetson Company, 1925 to date.
Director of Laboratories, Stetson Hospital, 1920 to date.
Editor, American Journal of Pharmacy, 1921 to date.
Associate Professor of Pharmacy, Philadelphia College of Pharmacy and Science 1914 to date.
Professor of Organic Chemistry, Wagner Free Institute of Science, 1926 to date.
Secretary of the Faculty of Wagner Free Institute of Science.
Fellow of the American Institute of Chemists.
Fellow of the American Association for the Advancement of Science.
Fellow of the Pennsylvania Academy of Science.
Member American Chemical Society.
Publications:
"Recent Remedies," 1926 (revised 1928). International Publications, N. Y.
"Popular Science Lectures" (Editor) (twelve volumes). Phila. College Pharmacy and Science, Phila.
U. S. Dispensatory (Collab. Editor). Lippincott, Phila.
Formula Book, A. Ph. A. (Editor). Lippincott, Phila.
Contributor to current chemical, pharmaceutical and medical literature.

GEORGE BRINGHURST KAISER

Educated in private schools.
Graduate, Franklin School.
After graduation spent several years in intensive botanical study and field work in northeastern United States.
Secretary of the Botanical Society of Pennsylvania for seven years and leader of its field trips.
Professor of Botany, Wagner Free Institute of Science, 1927 to date.
Curator, Moss Herbarium, Sullivant Moss Society.
Treasurer, Delaware Valley Naturalists' Union.
Member, Academy of Natural Sciences.

BENJAMIN FRANKLIN HOWELL

B.S., A.M., Ph.D., Princeton University.
Associate Professor of Geology and Paleontology, Princeton University.
Professor of Geology and Paleontology, Wagner Free Institute of Science, 1927 to date.
Curator of Invertebrate Paleontology and Stratigraphy in Princeton University.
Fellow of the Paleontological Society.
Secretary of the Paleontological Society.
Fellow of the Geological Society of America.
Fellow of the American Association for the Advancement of Science.
Member of the Palaeontologische Gesellschaft.
Associate Member of the Society of Economic Paleontologists and Mineralogists.
Member of the Committee on Micropaleontology of the National Research Council.
Chairman of Cambrian Subcommittee of U. S. National Research Council Committee on Stratigraphy.
Secretary of the Organization Committee of the International Paleontological Union.
Editor of the section of General Paleozoology of *Biological Abstracts*.
American Editor of *Palaeontologisches Zentralblatt*.
Specializes in Cambrian Paleontology and Geology.
Associated with U. S. Geological Survey, the U. S. National Museum, Geological Survey of Canada, Canadian National Museum, Geological Survey of Vermont, Geological Survey of Montana, Colorado School of Mines, as a consulting paleontologist and research associate.

REGULAR LECTURES, SESSION OF 1936–1937

BOTANY 2

PROFESSOR KAISER

Taxonomy

Lectures begin at 8 P. M.

1. Monday, September 14.
   Myxomycetes. Slime moulds. The borderland where plants and animals resemble each other.
2. Monday, September 21.
   Cyanophyceae. Blue-green algae. Early organisms of simple structure which appeared when the Earth's crust was cooling.
3. Monday, September 28.
   Schizomycetes. Bacteria. Types and kinds. Diseases of Man and of Plants. Good and bad traits.
4. Monday, October 5.
   Chlorophyceae. Phycomycetes. Green algae and algal fungi. Pond scums, desmids and diatoms. Moulds and mildews.

No Lecture October 12.

5. Monday, October 19.
   Phaeophyceae. Rhodophyceae. Brown and red seaweeds. Kelp, rockweed and gulfweed. Irish moss and dulse.
6. Monday, October 26.
   Ascomycetes. Sac fungi. Truffles and morels. Plant diseases. Ferment organisms: saccharomycetes.
7. Monday, November 2.
   Lichenes. Lichens. Dual organisms composed of algae and fungi. Soil building and reproduction.
8. Monday, November 9.
   Basidiomycetes. Basidio-fungi. Smuts and rusts. Serious diseases of farm crops. Plants that live on two hosts.
9. Monday, November 16.
   Basidiomycetes (continued). Fungi with gills. Edible and poisonous forms: Mushrooms and toadstools. Coral and bracket fungi. Puff-balls. Phosphorescence.
10. Monday, November 23.
    Hepaticae. Liverworts. Primitive green plants of thalloid and foliose forms. Alternation of generations: Gametophyte and sporophyte.
11. Monday, November 30.
    Musci. True mosses. Their life history and parts. Sphagnum, Andreaea and the great order Bryales.
12. Monday, December 7.
    Filices. True ferns. Their life history and parts. Adder's tongue and moonwort. The Polypody family. Species that love lime.
13. Monday, December 14.
    Other Pteridophyta. Fern allies. Water ferns, salvinia, horsetails, club mosses, ground pines and quillworts. Pteridosperms.

14. Monday, December 21.
    Gymnosperms. Naked-seeded plants. Life histories. Cycads and ginkgo. The yew, pine and other conifers. Gnetaceae.

Field Trip

The class in Botany will be conducted on a field trip under the leadership of Professor Kaiser. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

INORGANIC CHEMISTRY 4

PROFESSOR HORN

Chemistry of the Metals

Lectures begin at 7.45 P. M.*

1. Tuesday, September 15.
    Iron. Metallurgy: ore, mineral, gangue, flux, slag. Cast iron, white and gray. Wrought iron. Steels: open hearth, Bessemer, crucible. Tempering. Case-hardening.
2. Tuesday, September 22.
    Iron (Continued). Chemical properties of iron. Ferrous and ferric compounds. Analytical recognition. Photochemical properties. Blue printing. Biologic importance. Ink.
3. Tuesday, September 29.
    Copper. Principal ores. Native copper. Refining. Alloys. Chemical properties. Analytical recognition. Biologic occurrence. Electric cell.
4. Tuesday, October 6.
    Lead. Principal ores. Parke's process. Pattisonizing. Cupellation. Fire assay. Atomic weights of lead. Alloys. Chemical properties. Analytical recognition. Biologic effects. Storage batteries.
5. Tuesday, October 13.
    Mercury. Principal ores. Preparation. Refining. Amalgams. Chemical properties. Analytical recognition. Mercurous and mercuric compounds. Biologic effects. Fulminating mercury.
6. Tuesday, October 20.
    Gold and Platinum. Occurrence. Placer deposits. Free-milling ores. Cyanide process. Toning. Gold leaf. Alloys of gold; of platinum. Chemical properties. Platinum sponge. Platinum black. Catalysis.
7. Tuesday, October 27.
    Silver. Sources. Cupellation and parting. Plating. Alloys. Cleaning silver. Chemical properties. Analytical recognition. Biologic effects. Lunar caustic, colloidal silver, silver nitrate, indelible ink. Photosensitiveness. Daguerreotypes. Wet plates. Dry plates and films.
8. Tuesday, November 3.
    Cobalt and Nickel. Sources. Carbonyls. Mond process. Electro-deposition. Alloys. Monel metal. Chemical properties. Edison storage battery. Metal-ammines. Principal and secondary valence. Werner's hypothesis.
9. Tuesday, November 10.
    Cadmium and Tin. Sources. Metallurgy. Liquation. Alloys. Fusible metals. Chemical properties. Analytical recognition. Mordants. Tin salt. Tin plate and terne plate. Corrosion of metals. Recovery of tin.

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* Please note the hour.

10. Tuesday, November 17.

    Tungsten and Titanium. Sources. Chemical properties. Tungsten steel. Titaniferous iron ores. Tungsten filaments. Other uses.

11. Tuesday, November 24.

    Metallography. The phase rule. Eutectics. Thermal analysis. Determination of formulas of compounds neither isolated nor analyzed. Solid geometry of chemistry.

12. Tuesday, December 1.

    Bismuth and Molybdenum. Sources. Alloys. Chemical properties. Analytical recognition. Basic salts. Phosphomolybdates, and arsenomolybdates. Complex inorganic acids. Molybdenum steel.

13. Tuesday, December 8.

    Uranium and Rarer Metals. Sources. Chemical properties. Uranyl compounds. Transformation of elements. Emanations. Transmutation of metals. Modern alchemy.

14. Tuesday, December 15.

    Metallic Poisons. Industrial poisons. Germicides. Insecticides. Everyday hazards due to toxicity of metals.

ORGANIC CHEMISTRY 4

PROFESSOR GRIFFITH

Compounds of Nitrogen

Lectures begin at 8 P. M.

1. Wednesday, September 16.

   Nitrogen Itself. Inert alone but restless in company. An essential ingredient of all living tissue. Proteins. Classification. Identification. General characteristics.

2. Wednesday, September 23.

   Proteins. Their rôle in animal diet. Protein foods. Calorific value. Important proteins—gluten, gelatin, casein, etc.

3. Wednesday, September 30.

   Protein Derivatives. The body's way of simplifying the complex proteins by its schemes of digestion. Pepsin, trypsin, etc.

4. Wednesday, October 7.

   Protein Derivatives (Continued). Amino-acids, proteoses, peptones. The cinders of protein digestion—urea, creatinin, etc.

5. Wednesday, October 14.

   The Cycle of Nitrogen in Nature. Changing simple inorganic nitrogen compounds to complex organic bodies—and reverse. The nitrate beds of Chile. Soil and soil nutrition.

6. Wednesday, October 21.

   Man's Conquest of the Air. Not with wings, but with brains. Nitrogen fixation. Nitrogen—inactive—inert and useless—chained and put to work. The Haber process. Other fixation processes.

7. Wednesday, October 28.

   Miscellaneous Nitrogen Compounds. Vitamines and hormones. Regulators of living processes.

8. Wednesday, November 4.

   Miscellaneous Nitrogen Compounds (Continued). Purines, amines, urea, caffeine, theobromine and other odds and ends of nitrogen compounds.

9. Wednesday, November 11.
   Miscellaneous Nitrogen Compounds (Concluded). The cyanogen compounds. Plants that are poison factories. The bitter almond, wild cherry, peach, and hydrogen cyanide. Cyanamide.
10. Wednesday, November 18.
   Alkaloids. General characteristics. Origin—their rôle in plant life. Group reactions. Adsorption phenomena. Color reactions.
11. Wednesday, November 25.
   Alkaloids (Continued). The Pyridine and Tropine group—Coniine—the Socratic poison. Nicotine—the democratic poison. Atropine—the mydriatic poison. Cocaine—the anæsthetic poison.
12. Wednesday, December 2.
   Alkaloids (Continued). The Quinoline and Iso-quinoline groups. Quinine—bark of Peru, made famous by Jesuit fathers. Strychnine—the toxic and tonic alkaloid. Morphine, codeine, hydrastine, etc.
13. Wednesday, December 9.
   Alkaloids (Concluded). Artificial and miscellaneous alkaloids. Apomorphine, homatropine, heroine, emetine from ipecac, and sanguinarine from blood root.
14. Wednesday, December 16.
   Ptomaines and Allied Compounds. Ptomaines—toxins and toxalbumins. Facts and fallacies of food poisoning.

ENGINEERING 2

PROFESSOR WAGNER

Civil Engineering Structures

Lectures begin at 7.45 P. M.*

1. Friday, September 11.
   Foundations on Land. Designing the footing. Preparation of the bed.
2. Friday, September 18.
   Foundations on Land and Water. Foundations on piles. Cofferdams.
3. Friday, September 25.
   Foundations in Water. Open caisson process. Dredging through wells. Pneumatic caissons.
4. Friday, October 2.
   Masonry Construction. Stone masonry. Concrete. Brick masonry. Retaining walls, piers, etc.
5. Friday, October 9.
   Framing in Wood and Steel. Wood framing. Iron and steel framing. Joints. Rivets. Pins.
6. Friday, October 16.
   Bridges. Definitions. Classification. History. Beam bridges.
7. Friday, October 23.
   Bridges (Continued). Plate girders.
8. Friday, October 30.
   Bridges (Continued). Trusses. Classification. Design of tension and compression members.
9. Friday, November 6.
   Bridges (Continued). Trusses (Concluded). Details and methods of erection. Cantilevers.

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* Please note the hour.

10. Friday, November 13.
    Bridges (Continued). Suspension. Tubular. Arches—(a) stone, (b) steel.
11. Friday, November 20.
    Bridges (Concluded). Movable bridges. Viaducts.
12. Friday, November 27.
    Roofs. Types of trusses. Special designs for train sheds.
13. Friday, December 4.
    Details of Construction. Rivets. Riveted work, pins, forging details. Bridge floors—(a) railroad, (b) highway.
14. Friday, December 11.
    Buildings. Design of buildings of wood, steel, reinforced concrete, general building construction.

ZOOLOGY 1

PROFESSOR SCHMUCKER

Animals Without Backbones

Lectures begin at 8 P. M.

1. Monday, January 4.
   Where Animals and Plants Separate. They began alike, and slowly separated. Most plants settled down: most animals moved about. Most plants make food: animals only use it.
2. Monday, January 11.
   Animals of but One Cell. (Protozoa) This cell has all animal powers lightly developed. Such creatures increase rapidly and serve higher animals as food.
3. Monday, January 18.
   The Individual is Lost in the Colony. (Porifera) It is hard to distinguish the individual. The sponges have a skeleton, hard or horny, and have little definiteness of size or shape.
4. Monday, January 25.
   The Beginning of Better Things. (Coelenterata) A digestive system with mouth, stomach and tentacles. Settled polyps and swimming jelly fish. Alternation of generations. Coral islands.
5. Monday, February 1.
   Animals with Motion but with Little Decision. (Echinodermata) Here are good nutritive organs, but simple nerves. Skin is covered with spines. A plan of five rays.
6. Monday, February 8.
   Winning a Brain. (Vermes) Motion in one direction gave worms bilateral symmetry, and developed a brain in the front end. The absorbing skin tempted to parasitism.
7. Monday, February 15.
   Carrying their Homes. (Mollusca) The soft body is in a shell secreted by a mantle. The clams have right and left shell. Snails have an upper, spiraled shell. The squids a rear, coiled shell. Breathing is through siphons.

Monday, February 22. No lecture.

8. Monday, March 1.
   The Jointed Legged Animals. (Arthropoda) Here segmentation is very marked. Good sense organs develop on the head. Three great groups have each its own way of breathing.

9. Monday, March 8.
   Fitted for Water Living. (Crustacea) Lower forms are microscopic. Beach fleas, lobsters and crabs are progressively higher. Much used by man for food.

10. Monday, March 15.
   Breathing Air through Tubes. (Tracheata) The slime slug is a living fossil. Centipedes have many legs, insects but six. Simple and compound eyes. Insects vary enormously. Many species.

11. Monday, March 22.
   Spiders and their Kin. (Arachnida) Breathing by lung books. Eight legs and eight eyes. Poison glands. Web snares and homes. Degraded and primitive forms. "King Crabs."

12. Monday, March 29.
   Lowly Insects. Hoppers, Dragons and Bugs. The gradual development. The mating call. The meaning of wings. The biting mouth. Its modification for sucking. Insecticides.

13. Monday, April 5.
   Some Higher Insects. Flies, Beetles and Butterflies. Abrupt changes in development. Buzzing and humming. Insects often fertilize flowers. Do they choose their mates?

14. Monday, April 12.
   The Social Insects. Termites and their work. Bees, Solitary and Social. Wasps using mud and paper. The sting, its origin and purpose. Nectar and honey.

Field Trip

The class in Zoology will be conducted on a field trip under the leadership of Professor Schmucker. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

GEOLOGY 2

PROFESSOR HOWELL

Physical Geology

Lectures begin at 7.45 P. M.*

1. Tuesday, January 5.
   The Earth, Forever Changeable. The never ceasing ravages of time.

2. Tuesday, January 12.
   The Mighty Forces Within the Earth. The slow but endless changes they produce.

3. Tuesday, January 19.
   Volcanoes, the Smoke-stacks of Vulcan's Forge. The effects of their subterranean fires.

4. Tuesday, January 26.
   How Mountains Come to be Made. The various ways in which they have been formed.

5. Tuesday, February 2.
   How Mountains are Torn Down. The gnawing elements which wear away the high lands.

6. Tuesday, February 9.
   How the Mountains Flow Into the Oceans. How the débris of the high lands is carried downward to sea-level.

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* Please note the hour.

7. Tuesday, February 16.
   The War Between Land and Sea. The battles that rage at the shore line.
8. Tuesday, February 23.
   What the Sea Does With Its Spoils. How it sorts and distributes them over its floor.
9. Tuesday, March 2.
   The Waters Within the Earth's Crust. Their importance to modern man.
10. Tuesday, March 9.
    The Fuels Which We Get From the Earth's Crust. Coal and oil and how we discover them.
11. Tuesday, March 16.
    Ore Deposits, and How They are Formed. Iron, copper, lead, zinc, gold, silver, and other metals on which civilization depends.
12. Tuesday, March 23.
    Other Rocks That are Used by Man. Building and ornamental stones, asbestos, talc, mica, potash, borax, soda and salt.
13. Tuesday, March 30.
    The Soils In Which our Food is Grown. How they are formed and destroyed.
14. Tuesday, April 6.
    Geology and the Future of Our Race. How our grandchildren are to secure from the Earth's crust the raw materials which they will need.

Field Trip

The class in Geology will be conducted on a field trip under the leadership of Professor Howell. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

PHYSICS 3

PROFESSOR SEELY

Light

Lectures begin at 8 P. M.

1. Wednesday, January 6.
   Historical Development of the Theory of Light. Corpuscular theory. Newton. Electro-magnetic wave theory. The work of Huygens and Maxwell. Galileo. Rumford.
2. Wednesday, January 13.
   Propagation of Light. How light travels from its source and how its intensity varies as it travels. Shadows and their peculiarities in eclipses.
3. Wednesday, January 20.
   Propagation (Continued). Brightness of light and its illumination of objects. Measuring light and illumination. The speed at which light travels.
4. Wednesday, January 27.
   Interference and Polarization. The nature of a beam of light. Description of interference phenomena. Description of Polarized light and its uses.
5. Wednesday, February 3.
   Reflection of Light. How light is thrown back from a surface. Diffusing surfaces and mirrors. How images are formed by light from plane mirrors.
6. Wednesday, February 10.
   Reflection (Continued). How real and apparent images are formed by concave and convex mirrors.

7. Wednesday, February 17.

   Refraction. How light is bent as it passes from one medium into another having a different density. Lenses and prisms. How images are formed by lenses.

8. Wednesday, February 24.

   Dispersion of Light. How a beam of white light may be separated into its colors. Complementary colors. Pigments.

9. Wednesday, March 3.

   Color Phenomena. Coloration by partial absorbtion and reflection of white or colored light. Opalescence, phosphorescence and fluorescence.

10. Wednesday, March 10.

    Spectra. The spectrum or color band made by sun's light. Fraunhofer's lines. Bright-line and dark-line spectra. Some uses of the spectroscope.

11. Wednesday, March 17.

    Spectra (Continued). Invisible light beyond the red and violet ends of the visible spectrum. Composition of sun's light compared to that of artificial lights.

12. Wednesday, March 24.

    Optical Instruments. A study of the magnifying glass, the compound microscope, and the telescope.

13. Wednesday, March 31.

    Optical Instruments (Continued). The projection lantern and the motion picture machine. The stereoscope and binocular vision.

14. Wednesday, April 7.

    Photography. The photographic camera and the eye. How the image is fixed in the photograph or picture. Lens correction. Color photography.

MUSEUM TALKS

Monday evenings at 7 o'clock

This series comprises informal talks, given on Monday evenings in the Museum, illustrated by specimens.

Professor Howell

Minerals, Rocks and Fossils

Sept. 14. Minerals, Their Origins, Forms and Divers Uses.
Sept. 21. Igneous Rocks. Rocks Which "Froze" at High Temperatures.
Sept. 28. Stratified Rocks. The Hardened Sediments of the Earth's Crust.
Oct. 5. Plant Fossils. How Mother Nature Pressed Them Long Ago.
Oct. 12. No Lecture.
Oct. 19. Marine Fossils. The Contents of Davy Jones' Locker.
Oct. 26. Land Fossils. Shells, Footprints, Bones and Artifacts.

Mr. Lawrence

Animals of the Sea

Nov. 2. Little Known Animals of the Sea.
Nov. 9. Corals and Their Work on the Floor of the Sea.
Nov. 16. The Great Molluscan Groups of the Sea.
Nov. 23. The Great Crustacean Groups of the Sea.
Nov. 30. Some Special Types Among Fishes of the Sea.
Dec. 7. Air-breathing Animals of the Sea.

Professor Schmucker

Animals of the Land

Dec. 14. Animals living Underground.
Dec. 21. Ants and Their Ways.
Dec. 28. No Lecture.
Jan. 4. Squirrels and Their Kin.
Jan. 11. Beasts of Prey.
Jan. 18. Beasts of Burden.
Jan. 25. Monkeys and Apes.

Miss Borden

Animals That Fly

Feb. 1. What Flying Means. "Flying" Animals That do not Fly.
Feb. 8. Life Histories and Types of the Lower Flying Animals.
Feb. 15. Animals That Fly over Water.
Feb. 22. No Lecture.
Mar. 1. Animals That Fly over Land.
Mar. 8. Animals That Fly in the Dark.
Mar. 15. Migratory Flying Animals.

Professor Kaiser

Great Groups of Plants

Mar. 22. Duckweed, Dayflower and Pineapple.
Mar. 29. Sandalwood, Mistletoe and Dutchman's Pipe.
April 5. Buckwheat, Goosefoot, Pigweed and Poke.
April 12. Citron, Lemon, Orange and Their Close Kin.
April 19. Pinks and Portulacas.
April 26. Holly, Bittersweet, Bladdernut and Maple.

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Subjects of courses in each of the four successive years constituting a full term.

ENGINEERING

1. Materials of Engineering Construction.
2. Civil Engineering Structures.
3. Roads, Railroads and Tunnels.
4. Water Supply, Sewers, Canals, Rivers and Harbors.

PHYSICS

1. Properties of Matter. Mechanics.
2. Heat and Sound.
3. Light.
4. Electricity and Magnetism.

INORGANIC CHEMISTRY

1. General Principles, Notation, Nomenclature.
2. Descriptive Chemistry.
3. Descriptive Chemistry.
4. Descriptive Chemistry.

ORGANIC CHEMISTRY

1. General Principles, Aliphatic Hydrocarbons.
2. Carbohydrates, Fats, Oils and Waxes.
3. Cyclic Hydrocarbons.
4. Compounds of Nitrogen.

ZOOLOGY

1. Invertebrate Animals.
2. Vertebrate Animals.
3. Human Biology.
4. Principles of Animal Life.

BOTANY

1. Morphology.
2. Taxonomy.
3. Taxonomy (continued).
4. Physiology and Ecology.

GEOLOGY AND PALEONTOLOGY

1. Physical Geography.
2. Physical Geology.
3. Paleontology.
4. Historical Geology.

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1912.—Ancient Civilization of Babylonia and Assyria. *Morris Jastrow, Jr., Ph.D.*
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1931.—The Problems of the Origin and Antiquity of the American Aborigines in the Light of Recent Explorations. *Aleš Hrdlička, M.D., Sc.D.*
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1933.—Social Relations in Monkey, Ape and Man. *Robert M. Yerkes, A.M., Ph.D., Sc.D.*
1934.—Chemistry and Industrial Progress as exemplified in the Study of Hydrogen and Oxygen. *Hugh S. Taylor, D.Sc., F.R.S.*
1935.—Recent Progress in Astronomy *Samuel A. Mitchell, M.A., Ph.D., LL.D.*
1936.—Real Lilliputians of the Universe *Ellis L. Manning.*

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BULLETIN
of the
WAGNER FREE INSTITUTE OF SCIENCE
PUBLISHED BY THE INSTITUTE

SYDNEY L. WRIGHT, *Editor*

Vol. 11 | Quarterly | $1.00 per year
No. 4 | NOVEMBER, 1936 | Single numbers, 25 cents

A NEW TRILOBITE FROM THE LOWER CAMBRIAN OF ALBERTA

By BENJAMIN F. HOWELL, A.M., PH.D.

Some years ago Mr. John M. Birdsall collected from the Lower Cambrian St. Piran formation on the western side of Sentinel Pass, Alberta, an entire trilobite which is believed to be referable to a new species. He has presented the specimen to Princeton University, and has kindly permitted the writer to describe it.

The fossil is poorly preserved in a fine grained, slabby sandstone that is riddled with worm borings. It appears to be a mold of the under side of the test. It was found in a loose block which lay near the trail which runs from Moraine Lake, in the Valley of the Ten Peaks, over Sentinel Pass, into Paradise Valley, Alberta. It is named in honor of its discoverer.

This interesting trilobite appears to be related to two species described by Dr. C. D. Walcott* from the late Early Cambrian Mount Whyte formation of British Columbia and Alberta (which overlies the St. Piran formation) as *Olenopsis crito* and *Olenopsis? agnesensis* and to certain species described by Dr. Christian Poulsen† from the Early Cambrian Cape Kent formation of Northwest Greenland as *Inglefieldia porosa*, *I. planilimbata*, *I. discretà*, *I. groenlandica*, *I. inconspicua*, *I. thia*, and *Chancia venulosa*. As *Olenopsis crito* has been assigned by Dr. C. E. Resser to the genus *Kochiella*‡ and *Olenopsis? agnesensis* has been placed by the same authority in the genus *Alokistocare*§, the writer is in some doubt as to the genus to which his specimen should be referred. It appears to him not to be congeneric with either the genotype of *Kochiella*, *K. tuberculata* Poulsen, or the genotype of *Alokistocare*, *A. subcoronatus* (Hall and Whitfield). It is perhaps congeneric with the genotype of *Inglefieldia*, *I. porosa* Poulsen, although much larger than any of the species which Dr. Poulsen placed in *Inglefieldia*. In size it resembles

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* Walcott, C. D., Cambrian Geology and Paleontology, IV, no. 3.—Fauna of the Mount Whyte Formation, Smithsonian Miscellaneous Collections, vol. 67, no. 3, 1917, p. 75, 76, pl. 11, fig. 6, 6 a–b, pl. 13, fig. 5.

† Christian Poulsen, The Cambrian, Ozarkian and Canadian Faunas of Northwest Greenland, Meddelelser om Grønland, vol. 70, 1927, p. 261–265, pl. 15, fig. 19–24, pl. 16, fig. 1.

‡ C. E. Resser, Nomenclature of Some Cambrian Trilobites, Smithsonian Miscellaneous Collections, vol. 93, no. 5, 1935, p. 39.

§ Op. cit., p. 9.

Dr. Poulsen's *Chancia venulosa,* which Dr. Resser* refers to *Inglefieldia,* and Dr. Walcott's *Olenopsis crito,* which species, as noted above, Dr. Resser places in *Kochiella,* but which seems to the writer to belong rather in *Inglefieldia.* Unless debarred by its size, our species would seem to belong in *Inglefieldia,* and the writer is therefore describing it as *Inglefieldia? birdsalli.* The determination of its true generic position is made the more difficult by the fact that its facial sutures are poorly preserved. The discovery of better preserved specimens will permit of a more certain generic reference. It differs from *Alokistocare agnesensis* in having a larger number of thoracic segments and in details of the cranidium.

INGLEFIELDIA ? BIRDSALLI, NEW SPECIES

(Pl. I, fig. 1.)

All that is known of the form of this species is shown in the figure here presented. To be noted are the wide brim, the short genal spines, the mere trace of an intergenal spine, the 3 backward-arching and incomplete transverse furrows on the small, conical, bluntly truncated glabella, the long, closely fitting pleura (probably 20 in number), and the small pygidium, too poorly preserved to show its exact shape. The exact form of the eye lobes cannot be seen, but there appear to be traces of lobes similar in size and form to those of *Inglefieldia porosa.*

A very faint trace of what looks like a facial suture can be seen on the right side of the cephalon of our specimen, but its exact course can not be determined. If actually a suture, it seems to have had about the same course as the facial sutures of *Inglefieldia porosa* and "*Kochiella*" *crito.*

Dr. Poulsen classified *Inglefieldia* and *Kochiella* in the family *Ptychoparidae* of the order Opisthoparia.

Location of holotype. The holotype, which is the only known example of this species, is no. 41428 in the paleontological collection of Princeton University.

Age and locality. St. Piran formation, late Early Cambrian, on the western side of Sentinel Pass, Alberta.

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* Op. cit., p. 36.

EXPLANATION OF PLATES

PLATE I

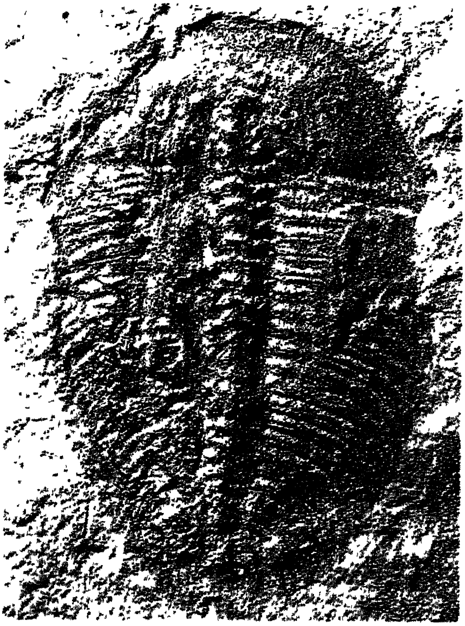
Fig. 1: *Inglefieldia ? birdsalli*, new species, St. Piran formation, on western side of Sentinel Pass, British Columbia.

PLATE II

Fig. 1: *Inglefieldia porosa* Poulsen (X1), after Poulsen, 1927, pl. 15, fig. 18.

Fig. 2: *Inglefieldia venulosa* (Poulsen) (X1), after Poulsen, 1927, pl. 16, fig. 1.

Fig. 3: "*Kochiella*" *crito* (Walcott) (X1), after Walcott, 1917, pl. 11, fig. 6.



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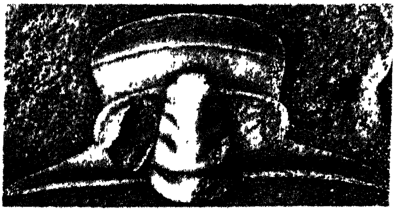

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BULLETIN
of the
WAGNER FREE INSTITUTE OF SCIENCE
PUBLISHED BY THE INSTITUTE
SYDNEY L. WRIGHT, *Editor*

Vol. 12 — Quarterly — $1.00 per year
No. 1 — FEBRUARY, 1937 — Single numbers, 25 cents

REEF-FORMING SERPULID FROM THE PLEISTOCENE OF SAN PEDRO, CALIFORNIA

By B. F. HOWELL, A.M., PH.D., and JOHN F. MASON

Tube-building Serpulid worms are abundant in modern seas, and their calcareous tubes are common fossils in some Cenozoic deposits. Usually these tubes are independently attached to some object on the sea-bottom. Sometimes many of them occur in a small area, and some of these overlap, so that one tube lies over, or across, another; but closely packed masses of such tubes are comparatively rare. Such colonial masses are, however, sometimes found.*

There are in the paleontological collection of Princeton University two specimens of this kind from the San Pedro Formation of Deadman's Island, San Pedro, California, which appear to be referable to a new species, which is here described. Both are subspherical masses of straight, or little curved, calcareous tubes, which are packed so tightly together that their walls are fused and the whole is a very porous, but solid, rock. These two ball-shaped specimens are presumably parts of a Serpulid reef, which were rolled about and rounded after being broken from the reef and before being permanently buried in the deposit from which they were collected.

One of these balls, the "holotype," here figured, is only 4 inches in diameter, but the other, the "paratype," is 19 inches across, and has been drilled into by boring pelecypods and gastropods.

The individual tubes vary in diameter from 1/8 to 1/16 of an inch. They are roughly circular in cross section, but are packed so closely together that they are usually somewhat oval, rather than perfectly circular. It is difficult to determine the length of individual tubes, but some of them can be determined to have been more than an inch long.

Since the generic classification of the Serpulid worms is based on the form of their soft parts, and not on their tubes, it is impossible for paleontologists to assign their fossils to genera. It has consequently become the custom to refer all fossil Serpulids to the type genus, *Serpula*, although many of them undoubtedly do not belong there. It seems to the authors that, while this practice is probably the best one that can be adopted, it is desirable to indicate by the use of quotation marks that the generic name, when thus used, is being employed in a peculiar way. Having chosen the specific name, *saxistructoris* (rock-builder), for their specimens, the authors would therefore write the full name as "*Serpula*" *saxistructoris*.

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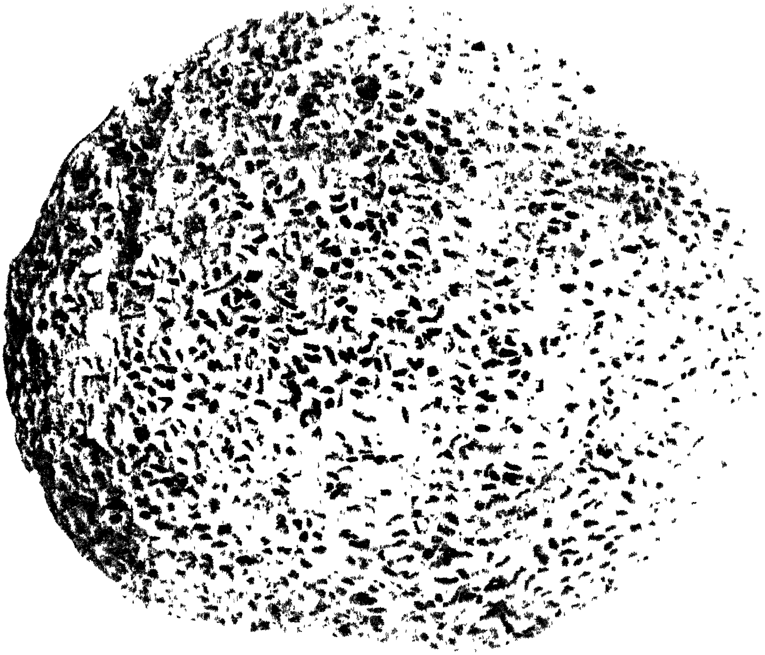
* See Howchin, W., Trans. Roy. Soc. South Australia, vol. 45, 1921, pp. 25–27, pl. 5.

The "holotype" of this new species is no. 42821 in the paleontological collection of Princeton University. The "paratype" is no. 42822 in the same collection. Strictly speaking, it is not feasible to designate a single tube as a holotype or paratype, and the smaller ball is therefore spoken of as the "holotype" and the larger ball as the "paratype."

Fig. 1: "*Serpula*" *saxistructoris*, new species. The "holotype" ball, × 1.

Fig. 2: Different view of the ball shown in Fig. 1 (×1) to show the details of individual tubes.



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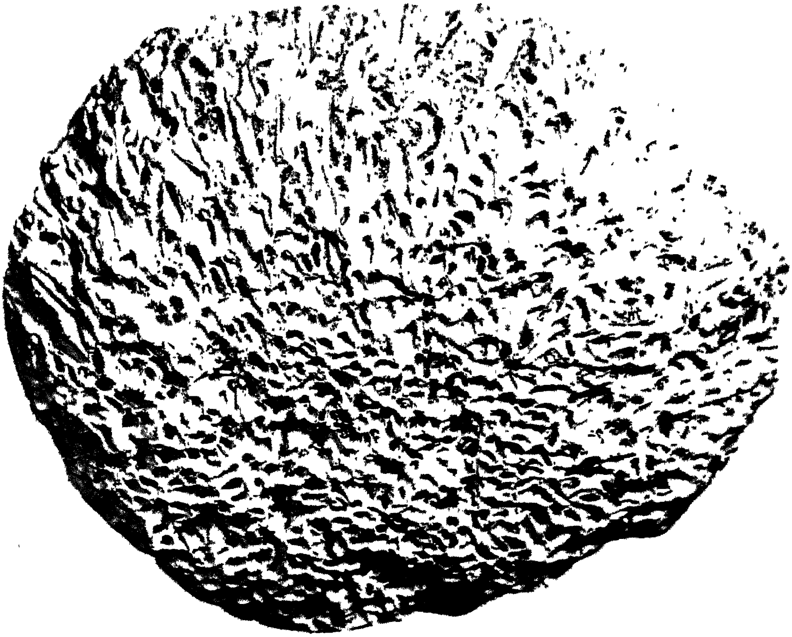

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BULLETIN
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Vol. 12 No. 2	Quarterly MAY, 1937	$1.00 per year Single numbers, 25 cents

A SYNOPSIS OF THREE LECTURES ON BIOLOGY AND SOCIAL PROBLEMS

(Delivered under The Richard B. Westbrook Free Lectureship, 1937)

BY EDWIN GRANT CONKLIN, PH.D., SC.D., LL.D.
Emeritus Professor of Biology, Princeton University

LECTURE I

BIOLOGY AND SOCIETY

1. *Nothing that concerns man is alien to biology.* Biology treats of all life, including human life. The morphology, physiology, development, evolution, genetics, ecology, behavior, and society of human beings are integral parts of biology. Indeed, the chief interest in the study of lower forms of life is in its contribution to the knowledge and welfare of man. Societies, whether of ants and bees or crows and wolves or apes and men, are based upon the same principles of organization, namely, individual differences and communal cooperation. These principles of differentiation and cooperation are found in all organisms from the simplest cells to the most complex animals. Societies are the most complex grades of organization that have ever appeared on earth.

2. *The chief method of science is the analysis of complex phenomena into simpler ones;* the principal means of analysis are comparison, development, and experiment.

(*a*) Comparison is the basis of all thinking and reasoning. We compare physical, chemical, and biological phenomena, noting their resemblances and differences. We compare individuals, races, and societies, noting their similarities and peculiarities. We say that we understand phenomena when we can correlate them with other phenomena, especially if we find that they have common causes.

(*b*) Development in autogeny or phylogeny is progress from the relatively simple to the more complex, and is a major method of analysis in the study of individuals, races, or societies.

(*c*) Experiment, wherever possible, is a more exact method of analysis. It is not often possible to purposely experiment on human beings and societies, but they often experiment on themselves and we can observe the results. Furthermore, animals and plants have been making experiments for millions of years. Long before man appeared on earth they had tried all possible methods of nutrition, reproduction, adaptation, and association; they had explored many paths that led to progress or degeneration and extinction. Our experiments in living are essentially similar to theirs; the basic problems of human society are those that concern nutrition, reproduction, adaptation, and cooperation, and it would be strange if we could learn nothing from the successes and failures of our predecessors on earth. But man has a larger degree of intelligence than any other animal, and intelligence makes possible many new experiments in living. By it we speed up or retard natural processes, combat enemies and diseases, prolong life, increase security and comforts, and in general control environment and thus improve on nature.

3. *Species and races of men.* Biology classifies man as an animal, a vertebrate, a mammal, a primate, each of which groups contains many genera and species. There is only one family of living men, namely, the *Hominidae;* one genus, *Homo;* and only a single species, *sapiens.* But there are at least four extinct genera of Hominidae and at least six extinct species, namely:

(1) Pithecanthropus erectus of Java.
(2) Sinanthropus pekingensis of China.
(3) Eoanthropus dawsoni of England.
(4) Paleoanthropus heidelbergensis of Germany.
(5) Homo rhodesiensis of Africa.
(6) Homo neanderthalensis of western Europe.

There are three primary races of existing men—the white, the yellow, and the black—and many sub-races and tribes. To a biologist, all of these are remarkably alike. All have essentially the same structures, functions, parasites, diseases, emotions, and instincts. All have the same number of chromosomes and many identical genes, and all are undoubtedly blood relatives.

Even intellectual and social traits are much alike in all races. All can be educated in the same schools, follow the same occupations and professions, and cooperate in the same society. Still there is a strong tendency to magnify beyond all science and reason such racial differences as exist. It is important, in these times of racial, national, and class antagonisms, to remember that all men are by nature brothers.

4. *The population problem.* In all living things the normal rate of reproduction is vastly greater than the survival rate. Even slow-breeding man has often doubled in numbers every twenty-five years; at this rate, if none died except from old age, there would not be standing room on the earth for the descendants of a single pair at the end of five hundred years.

In nature, populations are self-regulatory; overpopulation is prevented by—(1) lack of space and food; (2) unfavorable climate; (3) enemies and epidemics; (4) enormous destruction of seeds, eggs, and young. In many species millions of seeds or eggs perish for one that comes to maturity. Darwin says that a pair of bald eagles on the average brings to maturity only one pair in fifty years. Populations are generally stationary in nature, *i. e.*, the death-rate equals the birth-rate. Sudden departures from this rule are quickly regulated, as in the case of the English sparrow in America, or rabbits in Australia, or the Japanese beetle here.

In general, the higher the animal in the scale of life, the lower the birth-rate and the death-rate, *e. g.*, a starfish or oyster may produce 30,000,000 eggs annually, a codfish 5,000,000, a frog about 200 eggs, a bird from 1 to 20, mammals generally from 1 to 10 young, and yet the populations may remain constant.

Human population growth is like that of other mammals, except as modified by human intelligence and inventiveness. Sudden great increases in population are soon halted either by nature or by human purpose. Science created a population problem by increasing the means of living and decreasing the death-rate, but the dire predictions of Malthus, in 1789, have not been realized. The population of the world doubled between 1800 and 1900—that of Europe trebled, that of the United States quadrupled, and yet hunger and suffering are probably no greater now than in 1800.

The dangers of overpopulation are chiefly social rather than biological. Generally, where a high birth-rate is matched by a high death-rate, a species is maintained at maximum biological efficiency by means of the elimination of the less fit. But socially, overpopulation leads to lower standards of living and stimulates social conflicts and wars. The optimum population is neither the maximum nor the minimum. Populations may be too small as well as too large for the highest forms of culture. Our unemployment problem is not the result of overpopulation in the United States as a whole, but of poor distribution of population between cities and country, and poor distribution of work and goods.

In England and America the danger of underpopulation is at present much greater than of overpopulation. The best statistical evidence indicates that, in the absence of extensive immigration, we shall reach a stationary population within the next ten years and thereafter our numbers will slowly decline. This will cause great social changes within the next generation. It may even serve to raise the age limit of useful service, as it will surely bring a reduction in the number of children and young persons. A stationary population at optimum level is greatly to be desired, and young people should be made to realize that there is no greater social service than to leave worthy descendants in the world—no greater disservice than to breed knaves and fools.

5. *Sex and society.* This subject is generally taboo, but it deserves to be treated with scientific frankness. The significance or purpose of sex is the production of unique individuals, and this favors racial survival and evolution. To a large extent American women have won social, educational, and

political equality with men, but this does not mean sexual equality. The mammalian type of reproduction involves limitations of the freedom—possible number of offspring and length of reproductive period—of the female that are not imposed on the male.

Can woman ever have the same freedom as man? Only by abolition of maternity. Speculations on "ectopic reproduction," artificial rearing of human eggs and embryos, are probably vain imaginings. Equally improbable is the speculation that there may ever be "race mothers," as in ants and bees. If population remains stationary, every woman must bear at least three children, and for every one who has no children, some other woman must have six or more. It is better for the welfare and happiness of men and women and the human race that every normal person should mate and have children.

Various types of mating are found among mammals and men—promiscuity, polygamy, monogamy. Biologically all may be successful. Some of the greatest persons in history were bastards. Polygamous families in the Orient, Near East, and Utah may be very superior. Promiscuity and polygamy are condemned sociologically, not biologically; the former fails in protection of women and children; the latter condemns many men to be bachelors or eunuchs. Both are destructive of the highest type of family life. It is no accident that the most progressive and highly cultured peoples have renounced promiscuity and polygamy for monogamy. The family is the foundation of society; infantoria and asylums are poor substitutes for good homes. "The new freedom," when not balanced by a new sense of sexual and social responsibility, can end only in disaster.

LECTURE II

PRINCIPLES AND POSSIBILITIES OF HUMAN PROGRESS

1. *The idea of progress is relatively new*, and is founded largely on facts of development and the theory of evolution, but the popular idea of universal and inevitable progress is false. There has been regress as well as progress in evolution. Life cycles end in decay and death, and in the course of evolution it is probable that more species have become extinct than have survived. Nevertheless, in the course of geologic ages, there has been progress in certain lines.

There is abundant evidence of intellectual progress in the human race—progress in science and art and literature. There is also much evidence of social progress, as shown in decline of slavery, increasing justice, philanthropy, education, and better organization of governments. But human progress is neither universal nor inevitable. Progressive and regressive tendencies coexist, and if progress wins in the long run, it is through the elimination of the unfit and the survival of the fit.

2. *Fundamental factors of all development and progress are heredity and environment.* Heredity is intrinsic constitution; environment is the stimulus that acts on it. Environment may modify development, but it rarely changes heredity. There is no satisfactory evidence of the inheritance of acquired

characters, such as the effects of training or learning. Children do not inherit their mother tongue, but must learn it. They do not inherit the experience, skill, and learning of their parents. There is little hope of human progress by this route.

But while the acquirements of parents are not passed on to their children through the germ cells, they are transmitted through language, customs, and education, that is, through the social environment. Thus knowledge grows, but not the capacity to know. Civilization advances, but inheritance remains relatively unchanged.

3. *Social progress is largely the result of improved environment*, and not of improved heredity. In spite of medicine and surgery, there is wide-spread degeneracy and disease. In spite of general education, there is the alarming menace of low mentality. In spite of religion and ethics, there is much immorality and criminality.

4. *For lasting progress heredity as well as environment must be improved.* This is the program of eugenics. There is no doubt that heredity can be greatly improved by selective breeding, as is proved in the case of domestic animals. Within a few centuries a superior power could breed a healthier, more intelligent, more socially minded race of men. The principles of good breeding apply to man no less than to animals and plants, but the difficulty lies in enforcing them. However, much good can be wrought by eugenic education and enlightened public opinion. Prevention of the propagation of bad heredity is necessary, but it is less important than perpetuation of the good. The means of progress are improved environment and improved heredity, but there are certain basic principles which must be observed in applying these means.

5. *First among these is the principle of balance.* Life itself is balance between the organism and the environment. Ideal man is a proper balance of body, mind, and morals. Sanity is balance between emotion and reason. Society is based on a balance between the individual and the group, between rights and duties. In seeking means of progress balance must be preserved. Nietzsche and his followers would restore the "law of the jungle," forgetting that this would lose more for society than it would gain for the individual. A bloody brute may be physically fit, but socially unfit; a hulking giant may be feebleminded; a brilliant intellect may be found in a social rascal. In all progress a proper balance of desirable qualities is necessary.

Another necessary balance is between specialization and cooperation. These are companion principles of all progress. In human society specialization tends to outrun cooperation, as is illustrated by strikes, conflicts, and wars in the midst of high civilization. Lack of cooperation is one of the greatest dangers that threaten mankind.

Another necessary balance is that between instincts and intelligence, between emotions and reason. In social insects inherited instincts are undisturbed by intelligence, but in man intelligence may conflict with instincts and weaken cooperation. In all rational living intelligence must not be subordinate to instincts. The only hope for civilization is in learning to control animal passions by intelligence and reason.

In its present state the world cannot wait for the slow improvement of human heredity. This must be aimed at, but it probably will take thousands of years. Great progress can be made by the better development of the capacities we have, by better education, better habits, better morals. Many social evils have been abolished by education and enlightened public opinion, *e. g.*, human slavery, witchcraft, torture of heretics, duelling, and many others, and there is reason to hope that racial and national antagonisms and wars may at last be outlawed by better education and more rational social customs.

LECTURE III

BIOLOGY AND DEMOCRACY

I. *What is Democracy?*—The Declaration of Independence is the charter of our democracy. It holds "these truths to be self-evident, that all men are created equal; that they are endowed by their Creator with certain unalienable rights; that among these are Life, Liberty, and the pursuit of Happiness." More briefly, in the motto of France, democracy is "Liberty, Equality, Fraternity." These truths are not quite so self-evident now as in the days of revolution from the ancient régime, and many persons are asking, "Are they true?" What are the teachings of biology regarding these principles of democracy?

II. *Liberty, Individual and Social.*—The history of mankind has been an age-long struggle for freedom—freedom from the rigors and dangers of nature and from the tyrannies of men; freedom in thought, speech, religion, government, and industry. But in all societies personal liberty must be limited in the interest of social welfare. There is no absolute freedom in any society; fanatical extremes of liberty and anarchy find no successful counterpart in biology, where life and progress consist in balance and compromise between opposing forces or contrasting principles. In our social relations we forever sail the narrow sea between Scylla and Charybdis, between freedom and responsibility, liberty and duty.

A normal, living organism is the most nearly perfect type of organization known to man, and it has always been used as an example of what social organization should be. Aesop's fable, or St. Paul's parable of the conflict of the belly and the members, was intended to contrast the perfect organization of the body with the imperfect organization of society. In the normal body and in a completely organized society, such as that of ants and bees, we have the ideal of a perfect human society in which there is cooperation without compulsion, but this ideal has never yet been reached in human society.

Democratic freedom is not the freedom of isolation or anarchy, any more than the anarchy of the cancer cell represents the freedom of the cells of the body. It is not freedom from social control but freedom within social control, not freedom from law but freedom under law. And just as in the body the freedom of the cells is subordinate to that of the organs, and this to that of the entire body, so in society the freedom of the individual is subordinate to that of society. A free society is one based upon the free expression of the will of a majority of its members. A free government is one that is based upon the consent of the governed. This is democratic freedom, and its opposite can be seen in many other countries of the world. In view of what is happening elsewhere, we should sing of America with new spirit and understanding, "Sweet land of liberty . . . From every mountain-side, Let freedom ring," and the statue in New York Harbor should take on a new significance—"Liberty Enlightening the World."

III. *Democratic Equality vs. the Natural Inequalities of Men.*—Nothing is more evident than personal inequality. Men are born white, yellow, or black, with great or small mental capacity or potential value to society. I have often been asked, "Do you believe in heredity? How then can you believe in democracy?" Hereditary inequality is the strong fortress of aristocracy, but it is founded upon an obsolete idea of heredity. It confuses the human law of entail with the natural law of Mendelian inheritance.

Democratic equality does not mean that all men are created equal in personality, but rather that they are equal in the rights of life, liberty, and the pursuit of happiness. It is not a denial of personal inequality, but the only genuine recognition of it. Rigid family and class distinctions are denials of personal distinction. It does mean equal justice under law: no special privilege due to birth; freedom to find one's work and place in society; every man to be measured by his own merits and not by those of some ancestor whose good traits may have passed to a collateral line. Democracy alone permits of a natural classification of men as opposed to an artificial and conventional classification. This is what democratic equality means.

IV. *Fraternity.*—All men are cousins if not brothers; all trace back to common ancestors. Our lines of descent include kings and nobles and criminals. We hunt up our noble ancestors and forget the others. The most diverse races of men have more fundamental resemblances than differences. Often these differences are magnified beyond all science and reason, while the resemblances are forgotten. The emotions and instincts of men are more uniform than their intelligence and reason. "Many men of many minds," but their basal emotions are much the same. The social bond is largely emotional; therefore, in seeking social harmony or disharmony, the appeal to emotion is generally more successful than the appeal to reason.

Because of fundamental resemblances of all classes and races of men, and especially because of similarity of their emotions, it is possible for all men of good will to understand and sympathize with one another. No more effective means of promoting social harmony is possible than this ability to understand and sympathize and in thought to place one's self in another's position. If this teaching of biological fraternity were to be generally appreciated and practised, it would largely end the social conflicts that afflict mankind.

V. *Democracy may be slow and inefficient in operation, but it is educative for all who share it.* Should not this be one of the major functions of all government? Whether it be the government of children in a family or of individuals in society, should not the main purpose be to educate for the responsibilities of self-government? No doubt a wise and beneficent dictator can compel temporary order and progress; no doubt democracy is often disorderly and inefficient, misled by selfish politicians and grafters. But it is generally educative and sooner or later we "turn the rascals out." Dictatorships do not escape these evils, and they do not train the masses for responsible participation in government. Democracy rests upon a broad base and is relatively stable; autocracy is like a pyramid balanced on its apex and sooner or later it ends in disaster.

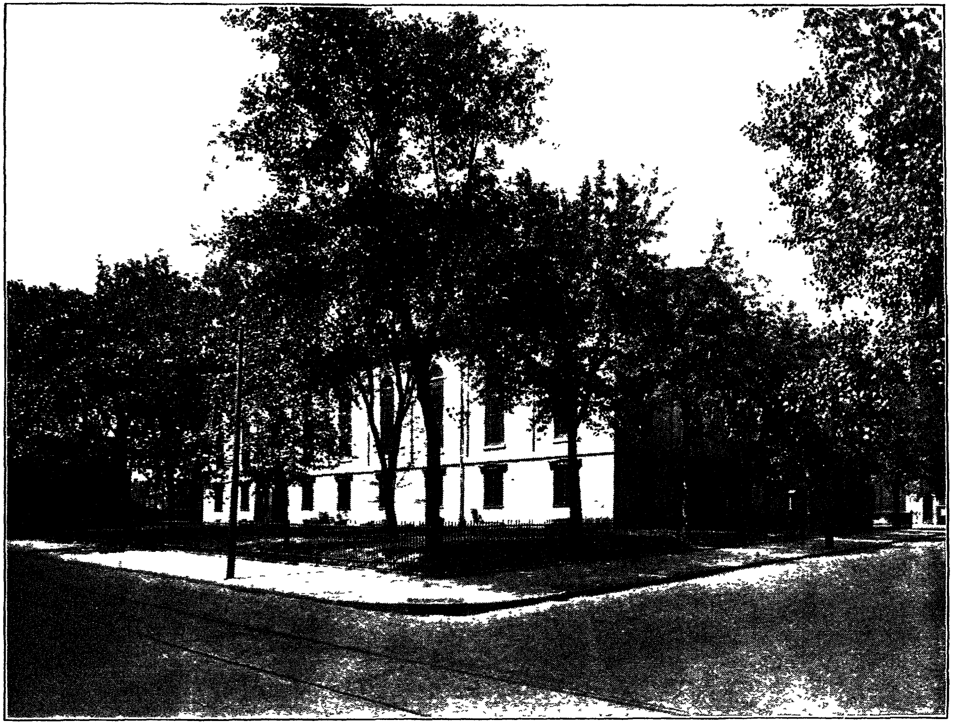
Democracy contributes more than any other social system to the peace and progress of a people. It brings a message of hope and inspiration to all classes and conditions of men. It inspires youth with visions and living examples of—

"Some divinely gifted man
Whose life in low estate began.

. . . .

And moving up from high to higher
Becomes on fortune's crowning slope
The pillar of a people's hope,
The centre of a world's desire."

This is the faith that fired the souls of our fathers, and there is no sufficient biological or social reason for thinking that it has been outgrown and must be abandoned.



THE WAGNER FREE INSTITUTE OF SCIENCE

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SYDNEY L. WRIGHT, *Editor*

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Department of Geology and Paleontology
Benjamin F. Howell, A.M., Ph.D.

Carl Boyer, *Director*

HISTORY

The Wagner Free Institute of Science was founded in 1847 by William Wagner, a citizen of Philadelphia.

In his early life William Wagner became associated with Stephen Girard in the extension of Girard's mercantile business. While in Girard's employ he had the opportunity to visit foreign countries, and being interested in scientific pursuits, he made a study of scientific institutions abroad and collected natural history specimens which afterward formed the nucleus for the collections in the museum of the Institute.

The Institute, itself, had its inception in a series of free lectures delivered by Professor Wagner in his home. These lectures, begun in 1847, were continued until 1855 when the Institute was incorporated by act of legislature.

A large measure of credit is due Mrs. Louisa Binney Wagner, Professor Wagner's wife, for sympathy, understanding and active coöperation in the early days of the founding of the Institute.

In 1855 a faculty was appointed and the work was continued in a new location at 13th and Spring Garden Streets, the City of Philadelphia giving permission for the use of Commissioners' Hall. Some years later Professor Wagner decided to erect a building on the present site at Seventeenth Street and Montgomery Avenue. This building was completed in 1865 and occupied immediately.

William Wagner died in 1885 and the management of the Institute was transferred to a Board of Trustees.

In 1901 a wing was added to the building for the use of a branch of the Free Library of Philadelphia.

INSTRUCTION

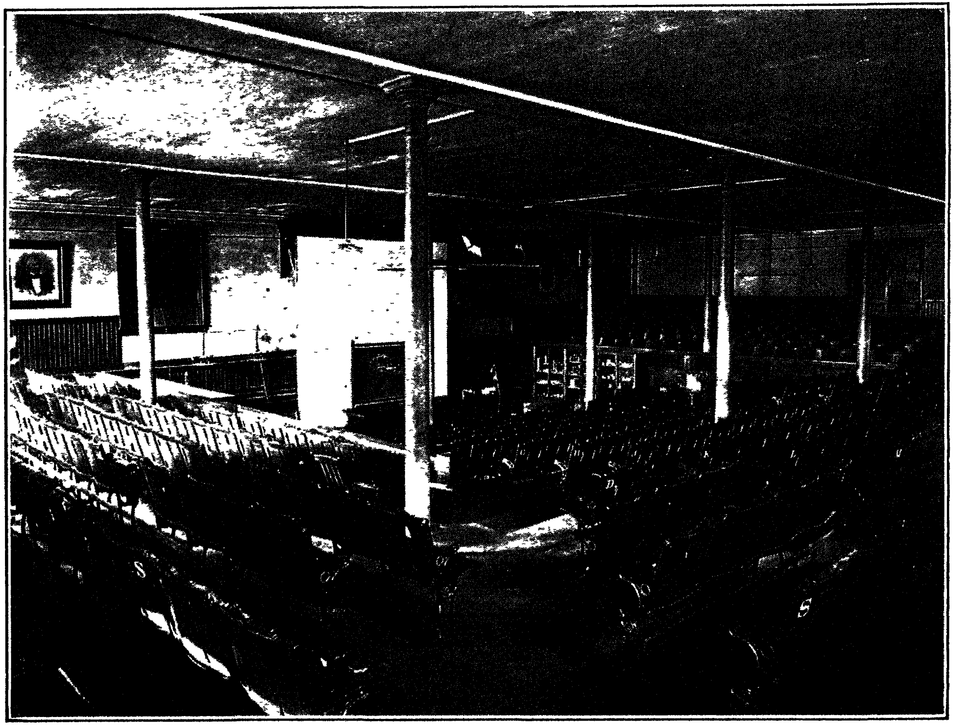
Lectures and Class-Work

Instruction at the Wagner Free Institute of Science is conducted by means of lectures supplemented by class work. There are no tuition fees.

Persons may attend lectures without registering for the classes if they so desire. Those registering for the classes are required to hand in a weekly paper and are admitted to an examination at the end of the term. Those persons successfully passing the examination are awarded certificates for the year's work.

There are seven courses of scientific lectures covering a period of fourteen weeks each for four years. On the successful completion of four years' work a Full Term Certificate is awarded.

The closing of each lecture season is marked by Commencement Exercises.



AUDITORIUM

MUSEUM

MUSEUM

The Institute maintains a natural history museum containing more than 21,000 specimens illustrating the various branches of natural science.

The collections are arranged especially for study. The museum is open to visitors on Wednesday and Saturday afternoons from 2 P.M. until 5 P.M., except legal holidays.

On each Monday evening at 7 P.M., from September to May, a "Museum Talk" is delivered in the museum, the speaker using the specimens in the museum to illustrate the lecture.

Teachers and students desiring to use the museum for special studies will be admitted upon application at the office.

LIBRARIES

The Reference Library of the Institute contains over 25,000 bound volumes and approximately 150,000 pamphlets on scientific subjects, classified and arranged for ready reference. There are also many foreign and domestic periodicals on file. The library is open to the public as well as to students from 10 A.M. to 9 P.M. daily, except Sunday.

The Free Library of Philadelphia maintains a branch library in the building, known as the Wagner Institute Branch, from which books may be taken out under the rules of the Free Library.

PUBLICATIONS

The publications of the Institute consist of three series:

Transactions: begun in 1885 and discontinued in 1927.

Publications: succeeding the Transactions. These Publications are issued at irregular intervals.

Bulletin: issued quarterly.

SPECIAL LECTURES

WESTBROOK FREE LECTURESHIP

The Westbrook Free Lectureship is supported by the income from an endowment provided by Dr. Richard Brodhead Westbrook and his wife, Dr. Henrietta Payne Westbrook. The lectureship was established in 1912 and provides for one course of lectures each year. These lectures cover a wide range of topics and a list of those so far given may be found on page 29.

FANNIE FRANK LEFFMANN MEMORIAL LECTURESHIP

The income of a fund given by Dr. Henry Leffmann is applied to occasional special lectures under the Memorial Lectureship. These lectures are popular in character.

The *Philadelphia Natural History Society* is affiliated with the Institute and holds meetings on the third Thursday of each month from October to May.

RESEARCH

The Institute has carried on research work since 1885 in various departments of science. Results of research have been published from time to time in the Transactions, Publications and Bulletin.

The Institute is also the recipient of the income from two funds established by Dr. Henry Leffmann. This income is devoted to research in chemistry.

CERTIFICATES AWARDED AT CLOSING EXERCISES, MAY 19, 1937

FULL TERM CERTIFICATES

BOTANY

John Dornan
Helen G. Durner
Eva M. Frank
Mary K. Gibbons
H. L. Grabosky
Herman H. Hofeld
Fannie S. Kirshner
Charles F. Summers

ORGANIC CHEMISTRY

William J. Boegly
Elizabeth T. Ewing
John F. Hardecker
Thomas H. Hart
Herman H. Hofeld
Anthony J. Schubert
Rudolph B. Smith, Jr.
David Travis
John H. Warnick

ENGINEERING

Willard C. Jones
James F. Mahoney
Andrew Pataky

INORGANIC CHEMISTRY

Ludwig M. Frank, Jr.
Thomas H. Hart
William G. Ramsey
Anthony J. Schubert
Rudolph B. Smith, Jr.
David Travis

ZOOLOGY

Myles Brazill
Robert J. Crawford
Herman H. Hofeld
William G. Ramsey
George F. Stauffer

GEOLOGY

John F. Hardecker
William G. Ramsey
David Travis
David B. Walker

PHYSICS

Thomas H. Hart
Herman H. Hofeld
William G. Ramsey
David Travis

1936-1937 CERTIFICATES

BOTANY 2

Ina Bein
Clifford Burnett
Elsie J. Burnett
Adon E. Burnham
John Dornan
Francis H. Doyle
Helen G. Durner
Nathan Fitelson
Eva M. Frank
Edward P. Frey
Wilma E. Gaines
Mary K. Gibbons
Florence H. Gillin
James R. Gillin
H. L. Grabosky
Eileen E. Hand
Louis E. Hand
Herman H. Hofeld
John G. Hope
John J. Kane
Fannie S. Kirshner
Harriette A. Lyon
Carroll R. McDonnell
Lilla P. Murdoch
Lola I. Poppleton
William G. Ramsey
Edith G. Rice
Dorothy Rouse
Margaret E. Scott
Charles F. Summers
Helen B. Vail

INORGANIC CHEMISTRY 4

John Berninger
Paul Collins
John M. Finn
Ludwig M. Frank, Jr.
Russell Friedbaum
Emma A. Frischeisen
Thomas H. Hart
William Heck
Virginia R. Hope
John A. Jewell
Harold Krelove
David W. Levy
Louis Moyd
Frederick A. Nixon
Donald O'Keefe
William G. Ramsey
Harold C. Ries
Anthony J. Schubert
Milton R. Sheen
Rudolph B. Smith, Jr.
Theodore H. Snyderman
Thomas L. Strong
Charles F. Summers
Joseph Sussna
David Travis
Ralph Wichterman
Philip Winkler

ORGANIC CHEMISTRY 4

John Berninger
William J. Boegly
Norman P. Breyer
Roscoe A. Davis
Elizabeth T. Ewing
John M. Finn
Russell Friedbaum
Emma A. Frischeisen
William T. Gane
John Grava
John F. Hardecker
Thomas H. Hart
Herman H. Hofeld
Margaret L. Hubbard
John A. Jewell
F. B. Johnstone
David W. Levy
John B. Palmer
William G. Ramsey
Otto J. Schoppe
Anthony J. Schubert
Clifford S. Shipley
Rudolph B. Smith, Jr.
Margaretta Splane
George F. Stauffer
Charles F. Summers
David Travis
John H. Warnick
George W. Webster
Ralph Wichterman
Philip Winkler

ENGINEERING 2

John M. Bley
Joseph P. Burke
Roscoe A. Davis
Bernard Dunn
Joseph S. Ferringo
Ralph A. Hafner
Elmer S. Jenkins
Willard C. Jones
John W. Kurtz
James F. Mahoney
L. Gilbert Obermiller
Andrew Pataky
Francis Sibre
Homer J. Stineman
Charles F. Summers
Arthur T. Tigue
George F. Werner

ZOOLOGY 1

Arthur S. Adams
Aaron Anton
George W. Baker, 4th
Ina Bein
Howard S. Birdsall
Myles Brazill
K. A. Broadbelt
Richard A. Burgin
Robert J. Crawford
Melvin L. Erben
George W. Fiddler
Beecher Finch
Martha Finch
Nathan Fitelson
Elinor A. Glackin
Eileen E. Hand
Richard C. Hayward
Gordon Hill
Herman H. Hofeld
John G. Hope
Harold H. Jones
Harriette A. Lyon
Blanche Manning
Caroll R. McDonnell
Margaret K. McKinley
William G. Ramsey
Ann Sayen
Milton Selig
George F. Stauffer
Lelia M. Stauffer
Thomas L. Strong
Charles F. Summers
Helen B. Vail

GEOLOGY 2

Beecher Finch
Arthur B. Guest
John F. Hardecker
Emanuel Hocking
H. May Hunter
Blanche Manning
Louis Moyd
William G. Ramsey
Charles F. Summers
David Travis
Helen B. Vail
David B. Walker

PHYSICS 3

Edward W. Barankin
Myles Brazill
John T. Campbell
Beecher Finch
Oscar F. E. Gentieu
Thomas H. Hart
Herman H. Hofeld
John A. Jewell
Louis Moyd
William G. Ramsey
Charles F. Summers
Gery L. Toole
David Travis
Philip Winkler

FACULTY

SAMUEL CHRISTIAN SCHMUCKER

A.M., M.S., Sc.D., Muhlenberg College.
Ph.D., University of Pennsylvania.
Professor of Biological Sciences, State Teachers College, West Chester, Pa., 1895–1923.
Science Department, Summer Schools, Chautauqua, N. Y., 1906–1928.
Lecturer on Biology, Brooklyn Institute of Arts and Sciences, 1905–1933.
Professor of Botany, Wagner Free Institute of Science, 1908–1926.
Professor of Zoology, Wagner Free Institute of Science, 1926 to date.
Dean of the Faculty.
Author of
"The Study of Nature." (Lippincott Co., Philadelphia.)
"The Meaning of Evolution." (Macmillan Co., N. Y.)
"Man's Life on Earth." (Macmillan Co., N. Y.)
"Heredity and Parenthood." (Macmillan Co., N. Y.)

JOHN WAGNER, JR.

B.S. in C.E. 1913, University of Pennsylvania.
C.E. 1920, University of Pennsylvania.
Assoc. M., Am. Soc. C. E.
1913–1916, Draftsman, Phoenix Bridge Company.
1916–1921, Office of Engineering Bridges and Buildings, Pennsylvania Railroad, including two years' service with the Army as First Lieut. and Captain in the Cavalry.
1921–1926, Assistant Supervisor Track, Reading Company.
1926–1928, Supervisor Track, Reading Company.
1928–1936, Industrial Agent, Reading Company.
1936 to date, Assistant General Freight Agent, Reading Company.
Professor of Engineering, Wagner Free Institute of Science, 1926 to date.

LESLIE BIRCHARD SEELY

Graduate, State Normal School, Bloomsburg, Pa.
Taught school, Luzerne and Snyder Counties, Pa.
Assistant instructor in physics and chemistry, Bloomsburg, 1899–1902.
Graduate, Haverford College, 1905.
Head Master, Friends Institute, Chappaqua, N. Y., 1905.
Instructor in physics, Northeast High School, Philadelphia, 1906–1915.
Head of Science Department, Germantown High School, 1915–1923.
Principal, Roxborough High School, 1923–1924.
Principal, Germantown High School, 1924 to date.
Graduate courses, University of Pennsylvania and Brooklyn Institute, 1906–1910.
Honorary degree of Doctor of Pedagogy, Ursinus College, 1926.
Professor of Physics, Wagner Free Institute of Science, 1912 to date.
Publications:
"Description of Two New Distomes," Biological Bulletin, Lancaster, Pa., 1906.
"Ether Waves and the Messages They Bring," Transactions of the Wagner Free Institute of Science.
"The Physics of the Three-electrode Bulb," Transactions of the Wagner Free Institute of Science.

DAVID WILBUR HORN

A.B., Dickinson College, 1897.
A.M., Dickinson College, 1898.
Ph.D., Johns Hopkins University, 1900.
Assistant in Chemistry, Johns Hopkins University, 1900–1901.
Associate and Associate Professor of Chemistry, Bryn Mawr College, 1901–1907.
Lecturer in Hygiene, Hahnemann Medical College, 1911 to date.
Head of Pre-Medical School of Science, Hahnemann Medical College, 1916–1921.
Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science, 1921 to date.
Professor of Inorganic and Physical Chemistry, Wagner Free Institute of Science, 1911 to date.

Chairman of Philadelphia Section of American Chemical Society, 1904 and 1905.
Fellow of American Association for the Advancement of Science.
Fellow of the Royal Society of Arts of London.

IVOR GRIFFITH

Early education at the Bethesda Academy, Wales, and came to America in 1907.
P.D., Philadelphia College of Pharmacy and Science, 1912.
Ph.M., Philadelphia College of Pharmacy and Science, 1921.
Sc.D. (Hon.), Bucknell, 1934.
Director of Research, John B. Stetson Company, 1925 to date.
Director of Laboratories, Stetson Hospital, 1920 to date.
Editor, American Journal of Pharmacy, 1921 to date.
Associate Professor of Pharmacy, Philadelphia College of Pharmacy and Science 1914 to date.
Professor of Organic Chemistry, Wagner Free Institute of Science, 1926 to date.
Secretary of the Faculty of Wagner Free Institute of Science.
Fellow of the American Institute of Chemists.
Fellow of the American Association for the Advancement of Science.
Fellow of the Pennsylvania Academy of Science.
Member American Chemical Society.
Publications:
"Recent Remedies," 1926 (revised 1928). International Publications, N. Y.
"Popular Science Lectures" (Editor) (twelve volumes). Phila. College Pharmacy and Science, Phila.
U. S. Dispensatory (Collab. Editor). Lippincott, Phila.
Formula Book, A. Ph. A. (Editor). Lippincott, Phila.
Contributor to current chemical, pharmaceutical and medical literature.

GEORGE BRINGHURST KAISER

Educated in private schools.
Graduate, Franklin School.
After graduation spent several years in intensive botanical study and field work in northeastern United States.
Secretary of the Botanical Society of Pennsylvania for seven years and leader of its field trips.
Professor of Botany, Wagner Free Institute of Science, 1927 to date.
Curator, Moss Herbarium, Sullivant Moss Society.
Treasurer, Delaware Valley Naturalists' Union.
Member, Academy of Natural Sciences.

BENJAMIN FRANKLIN HOWELL

B.S., A.M., Ph.D., Princeton University.
Associate Professor of Geology and Paleontology, Princeton University.
Professor of Geology and Paleontology, Wagner Free Institute of Science, 1927 to date.
Curator of Invertebrate Paleontology and Stratigraphy in Princeton University.
Fellow of the Paleontological Society.
Secretary of the Paleontological Society.
Fellow of the Geological Society of America.
Fellow of the American Association for the Advancement of Science.
Member of the Palaeontologische Gesellschaft.
Associate Member of the Society of Economic Paleontologists and Mineralogists.
Member of the Committee on Micropaleontology of the National Research Council.
Chairman of Cambrian Subcommittee of U. S. National Research Council Committee on Stratigraphy.
Secretary of the Organization Committee of the International Paleontological Union.
Editor of the section of General Paleozoology of *Biological Abstracts.*
American Editor of *Palaeontologisches Zentralblatt.*
Specializes in Cambrian Paleontology and Geology.
Associated with U. S. Geological Survey, the U. S. National Museum, Geological Survey of Canada, Canadian National Museum, Geological Survey of Vermont, Geological Survey of Montana, Colorado School of Mines, as a consulting paleontologist and research associate.

REGULAR LECTURES, SESSION OF 1937–1938

BOTANY 3

PROFESSOR KAISER

Taxonomy

Lectures begin at 8 P. M.

1. Monday, September 13.
   Gramineae. Cyperaceae. Grasses as food for man and beast and sedges a-plenty.
2. Monday, September 20.
   Palmae. Araceae. Useful palms and curious Jacks-in-the-pulpit.
3. Monday, September 27.
   Liliaceae. Amaryllidaceae. Iridaceae. The Big Parade of Lilies, Amaryllids and Irids.
4. Monday, October 4.
   Orchidaceae. Lovely and aristocratic orchids.
5. Monday, October 11.
   Betulaceae. Fagaceae. Graceful birches, spreading beeches and sturdy oaks.
6. Monday, October 18.
   Ranunculaceae. Nymphaeaceae. Magnoliaceae. Crowfoots in great variety, water lilies and magnolias.
7. Monday, October 25.
   Papaveraceae. Cruciferae. Sleep-inducing poppies and zestful mustards.
8. Monday, November 1.
   Rosaceae. Roses with a wealth of beautiful flowers and delicious fruits.
9. Monday, November 8.
   Leguminosae. The pea family with a host of plants useful to man.
10. Monday, November 15.
    Umbelliferae. Araliaceae. Cornaceae. Parsley, ginseng, dogwood and their kin.
11. Monday, November 22.
    Solanaceae. Scrophulariaceae. Wholesome and deadly nightshades and the figworts.
12. Monday, November 29.
    Rubiaceae. Caprifoliaceae. Beneficent quinine and honeysuckles twining or shrubby.
13. Monday, December 6.
    Cucurbitaceae. Luscious melons and the succulent squash.
14. Monday, December 13.
    Compositae. The great composite family—crown of the vegetable kingdom.

Field Trip

The class in Botany will be conducted on a field trip under the leadership of Professor Kaiser. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

INORGANIC CHEMISTRY 1

PROFESSOR HORN

General Principles. Notation. Nomenclature

Lectures begin at 7.45 P. M.*

1. Tuesday, September 14.
   Scope of Chemical Science. Distinctions between physical and chemical change. Characters of chemical change (color, odor, solubility. Other changes in properties). Necessity for intimate contact for reacting bodies. Velocity of chemical change.
2. Tuesday, September 21.
   Definiteness of Chemical Action. Law of indestructibility of matter. Law of definite proportion. Idea of the elements, and of chemical compounds.
3. Tuesday, September 28.
   Atomic Theory. Law of multiple proportions. Atomic weights. Symbols and their uses. Complexity of the atom. Electrons.
4. Tuesday, October 5.
   Hydrogen. Occurrence, preparation, properties. Use as a standard. Industrial uses.

   October 12 no lecture.
5. Tuesday, October 19.
   Oxygen. Occurrence, preparation, properties. Use as a standard. Industrial uses. Ozone. Allotropism.
6. Tuesday, October 26.
   The Common Properties of Gases. The gas laws; the general gas equation; the gas constant. The law of Gay-Lussac; Avogadro's hypothesis; molecular weights. The relation between atomic weights, chemical equivalents, and valence.
7. Tuesday, November 2.
   Molecular Theory. Formulas and their use. Representation of reactions by chemical equations. Complexity of molecules. Isomerism.
8. Tuesday, November 9.
   Chemical Forces. Law of chemical statics. Law of chemical kinetics. Historical views of chemical affinity. Chemical resistance. Valence. Transmutation of elements.
9. Tuesday, November 16.
   Water. Composition. Preparation of pure water. Decomposition by metals and non-metals. Hydroxids. Hydrates. Solutions. Importance to life. Heterogeneous equilibria and the phase rule. Hydrogen peroxid.
10. Tuesday, November 23.
    Electro-Chemical Phenomena. The tension series. Equivalence. Faraday's laws of electrolysis. Ionization. Strong and weak electrolytes. Neutralization. Indicators. Hydrolysis.
11. Tuesday, November 30.
    Principal Types of Inorganic Compounds. Oxids. Anhydrids. Salts. Nomenclature. Acid salts and basic salts. Radicles. Double salts, molecular compounds, and complexes.
12. Tuesday, December 7.
    Physical-Chemical Phenomena. Catalysts. Colloids. Osmotic pressure. Active and inactive molecules. Dissociation.

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* Please note the hour.

13. Tuesday, December 14.

    Air. History. Composition. Modern ideas of the structure of the atmosphere. The "Noble" gases. Oxidation and reduction. Industrial uses of air. Modern views on ventilation.

14. Tuesday, December 21.

    Elementary Ideas in Energetics. Law of conservation of energy; second law of thermodynamics. Kinetic theory; Waal's equation; states of matter. Solid and liquid phases; growth of crystals; crystal lattices; Mitscherlich's law. Thermochemistry; principle of maximum work.

ORGANIC CHEMISTRY 1

PROFESSOR GRIFFITH

General Principles: Aliphatic Hydrocarbons and Derivatives

Lectures begin at 8 P. M.

1. Wednesday, September 15.

    Nature and Composition of Organic Matter. Distinctions between the terms organic and inorganic. 1828—Wohler's discovery of urea synthesis—and changed concepts of organic chemistry. The Dawn of Creative Chemistry.

2. Wednesday, September 22.

    The Composition of Organic Matter. Where Carbon is King. Proximate and ultimate analysis. General tests for organic substances.

3. Wednesday, September 29.

    Transformations of Organic Matter in Nature. Fermentation—Putrefaction—Decay. Nature's scheme of circulation. The "ups and downs" of nitrogen.

4. Wednesday, October 6.

    Transformations of Organic Matter in the Laboratory. Destructive distillation, fractional distillation, substitution of elements and groups. Organometallic compounds. Builders of molecular structures.

5. Wednesday, October 13.

    Industries Based upon Fermentations of Various Kinds. Alcohol, acetone, glycerol, acetic acid, lactic acid, citric acid. Tanning, brewing, food and dairy industries.

6. Wednesday, October 20.

    Classification and Nomenclature of Organic Compounds. A study in names. Diaminodihydroxyarsenobenzene hydrochloride vs. sodium chloride. Complexity of organic terms necessary; each syllable means something to those who "run and read."

7. Wednesday, October 27.

    Molecular Structure. Isomerism, polymerism, metamerism. Einsteinian chemistry—stereochemistry and optical activity.

8. Wednesday, November 3.

    Hydrocarbons. Principal types. Homologous series. Paraffins (methanes). Petroleum. Gasolines, cleaning fluids and solvents.

9. Wednesday, November 10.

    Paraffins (methanes) (Continued). Natural gas and its derivatives. Coal gas, bitumens, etc.

10. Wednesday, November 17.

    Olefins (ethenes). Derivatives of hydrocarbons. Alcohol radicles.

11. Wednesday, November 24.

    Alcohols. Ethyl and Methyl, the alcohol twins. Proof spirit, denatured alcohols, medicated alcohols, industrial alcohols. Other alcohols used in the arts and industries. Alcoholic beverages.

12. Wednesday, December 1.

    Aldehydes. Acetaldehyde, formaldehyde and their polymers. Their industrial applications.

13. Wednesday, December 8.

    Ethers and Esters. Scent and flavor owe their favor, mostly to these twins. Esterification, hydrolysis, saponification.

14. Wednesday, December 15.

    Esters (Concluded). Commercial uses of ethers and esters. Industrial solvents. The great lacquer industry. Imitation fruit flavors.

ENGINEERING 3

PROFESSOR WAGNER

Roads, Railroads and Tunnels

Lectures begin at 7.45 P. M.*

1. Friday, September 10.

    Engineering Location. Surveying. Measuring straight lines. Measuring angles. Field work.

2. Friday, September 17.

    Engineering Location (Continued). Vertical measurements. The "Y" level. Barometer. Topography. Field work.

3. Friday, September 24.

    Roads and Pavements. Definition. Reconnaisance. Preliminary surveys. Maps. Profiles. Location.

4. Friday, October 1.

    Roads and Pavements (Continued). Earthwork. Drainage. Foundations.

5. Friday, October 8.

    Roads and Pavements (Continued). Surfacing. Natural dirt roads. Gravel roads. Broken stone roads.

6. Friday, October 15.

    Roads and Pavements (Concluded). Granite block, asphalt, wood and concrete pavements.

7. Friday, October 22.

    Railroads. Economic location. Railroad curves. Field work.

8. Friday, October 29.

    Railroads (Continued). Earthwork. Drainage. Ballast. Ties.

9. Friday, November 5.

    Railroads (Continued). Rails. Frogs. Switches. Crossings.

10. Friday, November 12.

    Railroads (Continued). Signals: block; interlocking. Turntables. Snow sheds and fences. Rolling stock and locomotives.

11. Friday, November 19.

    Railroads (Continued). Stations. Terminals. Bridges. Elevated railroads.

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* Please note the hour.

12. Friday, November 26.
    Railroads (Concluded). Underground railroads. Use of electricity. Street railways. Rack railroads.

13. Friday, December 3.
    Tunnels. Location. Shafts. Heading. Driving in soft ground; in rock. Blasting. Explosives. Ventilation.

14. Friday, December 10.
    Tunnels (Concluded). Cross sections. Packing. Submarine tunnels.

ZOOLOGY 2

PROFESSOR SCHMUCKER

Animals with Backbones

Lectures begin at 8 P. M.

1. Monday, January 3.
   Winning a Backbone. Missing links and their slow cousins. Acorn tongued worms and sea-squirts. The lancelet tells the story.

2. Monday, January 10.
   Fish Holdovers from Past Ages. The lamprey carries on. Sharks hold their own, or flatten into rays. Lungfish report an old prophecy.

3. Monday, January 17.
   Aristocrats Amongst the Fishes. Fishes are splendidly adapted to their station in life. Adaptive radiation comes in. The fundamental skeleton.

4. Monday, January 24.
   Vertebrates Come Out of the Water (Amphibians). Fins change to limbs and lungs appear. The Salamander foretells all the rest. Frogs draw in their tails. Young still are like fishes.

5. Monday, January 31.
   How Reptiles Reigned and Dwindled. Reptiles pushed tadpole stage back into the egg. They had few enemies and developed rapidly. Cold nearly cut them off.

6. Monday, February 7.
   Some Reptiles Changed to Birds. First rose on hind feet and gained a better circulation. Scales change to feathers, and front legs to wings. The finest "missing link."

7. Monday, February 14.
   Birds of Philadelphia. The Gulls and Ducks of the rivers. Waders of the marshes. Pigeons about City Hall. The introduced Sparrows and Starlings. Hawks and Owls come to town. Song birds in the parks.

8. Monday, February 21.
   How Mammals Learned to Give Milk. They kept their fertilized eggs inside the body to develop. Warm blood called for fur. Skin glands learned to secrete milk for the young.

9. Monday, February 28.
   The Nibbling Rabbit and His Kind. Protected by coloration and by shyness. Teeth became chisels for bark. How rodents meet the cold of winter.

10. Monday, March 7.
    How the Horse Lost His Toes. The original number of vertebrate toes was five. Dogs lost one; pigs and cows three, on each foot. Legs lengthened for speed. Teeth developed heavy grinders.

11. Monday, March 14.

    Killers in the Animal World. Carnivorous animals and their meat diet. Teeth and claws for capturing prey. Bears lowly in the group. Dogs are cooperative. Cats are solitary, and come out on top.

12. Monday, March 21.

    How the Whale Got Into the Sea. Whales, porpoises, seals and sea lions were once land animals of different orders. As were all mammals. Adaptations for water life. Coming up for air.

13. Monday, March 28.

    Man's Lowly Cousins. The primates begin with the lowly Lemurs. They rise through New World, then Old World, monkeys. Highest of all are the few kinds of apes.

14. Monday, April 4.

    The Mental Life of the Apes. My own studies with Chimpanzee and Orang. Their spontaneous activities. Purpose evident in their actions. Their emotional life.

Field Trip

The class in Zoology will be conducted on a field trip under the leadership of Professor Schmucker. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

GEOLOGY 3

PROFESSOR HOWELL

Paleontology

Lectures begin at 7.45 P. M.*

1. Tuesday, January 4.

    The Roots of Life, Deep Buried in the Past. How paleontologists uncover and study them.

2. Tuesday, January 11.

    How Did Life Begin on the Earth? Different theories of the origin of life.

3. Tuesday, January 18.

    The Evolution of Skeletons and Armor. How and why plants and animals came to build hard parts in and about their bodies.

4. Tuesday, January 25.

    How the Plants Crossed the Strand Line. Their difficult adaptation to a land life.

5. Tuesday, February 1.

    The First Forests. The giant fern-like trees of the great coal swamps.

6. Tuesday, February 8.

    The Flowers Come to Beautify the World. The evolution of blossoms and fruits.

7. Tuesday, February 15.

    The Animals Which Fed on the Plants. How plant life made animal life possible.

Tuesday, February 22. No lecture.

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* Please note the hour.

8. Tuesday, March 1.

   The Rapid, Branching, Evolution of the Animals. The problems of nomenclature and classification which this evolution has presented to paleontologists.

9. Tuesday, March 8.

   The Protozoans and Their Colonial Descendants. How the many-celled animals evolved from their one-celled ancestors.

10. Tuesday, March 15.

    The Many-celled Animals Learn to Crawl and Swim. The worms and the echinoderms.

11. Tuesday, March 22.

    The Rise and Decline of the Brachiopods. A group of animals long abundant in the seas, but now almost extinct.

12. Tuesday, March 29.

    The Mollusks, Whose Armor Has Enabled Them to Survive. The clams, oysters, snails, and squids and their relatives.

13. Tuesday, April 5.

    The Jointed-legged Horde. The arthropods and their adaptations to many modes of life.

14. Tuesday, April 12.

    Our Own Phylum, the Chordata. The animals which now dominate the earth.

Field Trip

The class in Geology will be conducted on a field trip under the leadership of Professor Howell. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

PHYSICS 4

Professor Seely

Electricity and Magnetism

Lectures begin at 8 P. M.

1. Wednesday, January 5.

   How man's knowledge of electricity began and how it grew. How stationary electric charges are produced. The law of attraction and repulsion. Potential and capacity. Action of points. Lightning.

2. Wednesday, January 12.

   How electric currents are caused and controlled. Voltaic cells. What is an "electric current"? Electromotive force or pressure. Local action. Polarization. Open- and closed-circuit cells. Thermoelectric cells.

3. Wednesday, January 19.

   The flow of electricity in circuits. Conductivity. Resistance. Pressure and amount of flow. Ohm's law. Electric units. Specific resistance.

4. Wednesday, January 26.

   The flow in circuits (continued). Resistance in wire circuits. Circuits in parallel and in series. Shunts. Fall in pressure along a circuit. Connection of cells in parallel and in series.

5. Wednesday, February 2.

   The flow in circuits (concluded). Heat effects of current. Electrical work and power. Conservation of energy. Relation of electrical units to those of heat and mechanical energy.

6. Wednesday, February 9.

   The flow of electricity through liquids. Chemical effects. Laws of Faraday. Chemical equivalent and electrochemical equivalent. Voltameters.

7. Wednesday, February 16.

   The growth of our knowledge of magnetism. Natural and artificial magnets. The law of magnetic attraction and repulsion. Molecular magnetism. Magnetic fields. Terrestrial magnetism.

8. Wednesday, February 23.

   How magnetism and electricity are related. Effects of a current on a magnetic needle. Magnetic field produced by a current. Coils and electromagnets. Permeability and reluctance. The magnetic circuit.

9. Wednesday, March 2.

   Getting a current from a magnetic field. A conductor cutting lines of force. Magnetos. Direction and magnitude of induced pressure. Action of coils in magnetic fields. Induction coils. Lenz's Law.

10. Wednesday, March 9.

    Instruments for measuring pressure and current. Galvanometers. Voltmeters and ammeters. Wattmeters.

11. Wednesday, March 16.

    How resistance of conductors is measured. Measurement by substitution. Resistance boxes. Wheatstone's Bridge. The ammeter-voltmeter method.

12. Wednesday, March 23.

    How current is made and used commercially. Direct dynamos and motors. Field magnets. Bi-polar and multi-polar machines. Armatures. Commutators. Series, shunt and compound windings.

13. Wednesday, March 30.

    Some differences between alternating and direct currents. Representation of currents by curves. Self-induction. Measuring instruments for alternating currents.

14. Wednesday, April 6.

    Some facts and some theories concerning electricity and matter. Passage of electricity through gases. Radium and its products. Molecular nature of electricity.

MUSEUM TALKS

Monday evenings at 7 o'clock

This series comprises informal talks, given on Monday evenings in the Museum, illustrated by specimens.

PROFESSOR HOWELL

Minerals, Rocks and Fossils

Sept. 13. Minerals, the Most Beautiful Things in the Earth's Crust.
Sept. 20. The Rocks Which are Made up of These Minerals.
Sept. 27. Minerals and Rocks of Special Value to Man.
Oct. 4. Fossils, the Most Interesting Things in the Earth's Crust.
Oct. 11. Plant Fossils, which Tell us the Story of the Vegetation of the Past.
Oct. 18. Animal Fossils, which tell us how we and the Other Modern Animals Evolved.

MISS BORDEN

How Animals Feed

Oct. 25. How the Lowest Animals Feed.
Nov. 1. Learning to Capture Food.
Nov. 8. The Development of Mouth Parts.
Nov. 15. Special Structures for Feeding.
Nov. 22. How Birds Feed.
Nov. 29. How Mammals Feed.

MR. LAWRENCE

How Animals Meet Their Enemies

Dec. 6. How the Simple Animals of the Sea Protect Themselves.
Dec. 13. Fish and Their Enemies.
Dec. 20. Methods of Protection Among Insects and Spiders.
Dec. 27. No Lecture.
Jan. 3. Birds' Strategies and Their Enemies.
Jan. 10. How Reptiles and Amphibians Outwit Their Enemies.
Jan. 17. Mammals and Their Fight for Life.

PROFESSOR SCHMUCKER

How Animals Provide for Their Young

Jan. 24. Frogs and Their Jellied Eggs.
Jan. 31. Turtles and Their Buried Eggs.
Feb. 7. Birds that Nest on the Ground.
Feb. 14. Birds that Nest in Trees.
Feb. 21. How the Opossum Pockets Her Young.
Feb. 28. Rabbits and Their Bunnies.

PROFESSOR KAISER

Great Groups of Plants

Mar. 7. Willows and Walnuts.
Mar. 14. Nettle, Elm, Fig and Breadfruit.
Mar. 21. Spurges and Starwort.
Mar. 28. Lindens and Mallows.
Apr. 4. St. John's Wort, Rock Rose, Violet and Passion Flower.
Apr. 11. Myrtle, Loosestrife and Evening Primrose.

GENERAL SCHEDULE OF REGULAR LECTURES

Subjects of courses in each of the four successive years constituting a full term.

ENGINEERING

1. Materials of Engineering Construction.
2. Civil Engineering Structures.
3. Roads, Railroads and Tunnels.
4. Water Supply, Sewers, Canals, Rivers and Harbors.

PHYSICS

1. Properties of Matter. Mechanics.
2. Heat and Sound.
3. Light.
4. Electricity and Magnetism.

INORGANIC CHEMISTRY

1. General Principles, Notation, Nomenclature.
2. Descriptive Chemistry.
3. Descriptive Chemistry.
4. Descriptive Chemistry.

ORGANIC CHEMISTRY

1. General Principles, Aliphatic Hydrocarbons.
2. Carbohydrates, Fats, Oils and Waxes.
3. Cyclic Hydrocarbons.
4. Compounds of Nitrogen.

ZOOLOGY

1. Invertebrate Animals.
2. Vertebrate Animals.
3. Human Biology.
4. Principles of Animal Life.

BOTANY

1. Morphology.
2. Taxonomy.
3. Taxonomy (continued).
4. Physiology and Ecology.

GEOLOGY AND PALEONTOLOGY

1. Physical Geography.
2. Physical Geology.
3. Paleontology.
4. Historical Geology.

LECTURES UNDER RICHARD B. WESTBROOK FOUNDATION

1912.—Ancient Civilization of Babylonia and Assyria. *Morris Jastrow, Jr., Ph.D.*

1913.—Conservation of Natural Resources. *Gifford Pinchot, Marshall O. Leighton, Overton W. Price, Joseph A. Holmes.*

1914.—The Theory of Evolution. *William Berryman Scott, Ph.D., LL.D.*

1915.—Invisible Light. *Robert Williams Wood, LL.D.*

1916.—Aspects of Modern Astronomy. *John Anthony Miller, A.B., A.M., Ph.D.*

1917.—Heredity and Evolution in the Simplest Organisms. *H. S. Jennings, B.S., A.M., Ph.D., LL.D.*

1918.—The Chemistry, Nutritive Value and Economy of Foods. *Harvey W. Wiley, A.M., M.D., B.S., Ph.D., LL.D., D.Sc.*

1919.—The Origin and Antiquity of the American Indian. *Aleš Hrdlička, M.D., Sc.D.*

1920.—Chemistry and Civilization. *Allerton S. Cushman, B.S., A.M., Ph.D.*

1921.—Microbiology. *Joseph McFarland, M.D., Sc.D.*

1922.—Evolution of the Human Face. *William K. Gregory, Ph.D.*

1923.—The Philosophy of Sanitation. *George C. Whipple, B.S.*

1924.—The Distribution of American Indian Traits. *Clark Wissler, A.M., Ph.D.*

1925.—Structural Colors. *Wilder D. Bancroft, Ph.D., Sc.D.*

1926.—The Animal Mind; its sources and evolution. *George Howard Parker, Sc.D.*

1927.—An Interpretation of Atlantic Coast Scenery. *Douglas W. Johnson, Ph.D.*

1928.—The Science of Musical Sounds. *Dayton C. Miller, Ph.D.*

1929.—Volcanoes and Vulcanism. *William B. Scott, Ph.D., LL.D.*

1930.—Present Problems of Evolution. *Edwin Grant Conklin, Ph.D., ScD., LL.D.*

1931.—The Problems of the Origin and Antiquity of the American Aborigines in the Light of Recent Explorations. *Aleš Hrdlička, M.D., Sc.D.*

1932.—Common Sense, Science and Philosophy. *John Dewey, Ph.D., LL.D.*

1933.—Social Relations in Monkey, Ape and Man. *Robert M. Yerkes, A.M., Ph.D., Sc.D.*

1934.—Chemistry and Industrial Progress as exemplified in the Study of Hydrogen and Oxygen. *Hugh S. Taylor, D.Sc., F.R.S.*

1935.—Recent Progress in Astronomy *Samuel A. Mitchell, M.A., Ph.D., LL.D.*

1936.—Real Lilliputians of the Universe *Ellis L. Manning.*

1937.—Biology and Social Problems *Edwin Grant Conklin, Ph.D., Sc.D., LL.D.*

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The Theory of Evolution, by *William Berryman Scott.* The Macmillan Co.

Life and Death, Heredity and Evolution in Unicellular Organisms, by *H. S. Jennings.* Richard G. Badger.

Chemistry and Civilization, by *Allerton S. Cushman.* Richard G. Badger.

Fighting Foes too Small to See, by *Joseph McFarland.* F. A. Davis Co.

The Relation of Nature to Man in Aboriginal America, by *Clark Wissler.* Oxford University Press.

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Vol. 1.—Explorations on the West Coast of Florida and in the Okeechobee Wilderness. *Angelo Heilprin.* $2.50

Vol. 2.—Report on Fresh-water Sponges Collected in Florida. *Edward Potts.*
Notice of Some Fossil Human Bones. *Joseph Leidy.*
Description of Mammalian Remains from Rock Crevice in Florida. *Joseph Leidy.*
Description of Vertebrate Remains from Peace Creek, Florida. *Joseph Leidy.*
Notice of Some Mammalian Remains from Salt Mine of Petite Anse, Louisiana. *Joseph Leidy.*
On Platygonus, an Extinct Genus Allied to the Peccaries. *Joseph Leidy.*
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Bulletin of the Institute. Quarterly $1.00 per year
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Illustrated Catalog of North American Devonian Fossils, Unit 7B, Ammonoidea. $2.50 (Plus Packing and Postage). Unit 9A, Beyrichiacea, $5.50 (Plus Postage).

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TWO NEW SPONGES FROM THE SILURIAN OF TENNESSEE

By BENJAMIN F. HOWELL, A.M., PH.D.

Perryville, in Perry County, Tennessee, has long been famous among students of Silurian paleontology as a locality for fossil sponges. Many beautiful specimens of Astylospongidae have been collected from this region, and a number of species and varieties have been described.

Sponges, unlike most other animals, do not always have a definite form, which is essentially the same for every individual of a given species. While their spicules are constant in shape, the bodies of many kinds of sponges vary more or less in form. This variability often makes the specific identification of a sponge a difficult problem. This is especially true in the case of many fossil species. It is true of many of the Astylospongidae found in the Middle Silurian (Niagaran) rocks of the Brownsport Formation of Perry County, where a number of related species and varieties of Astylospongids appear to have lived together in Medial Silurian times. The fossilized bodies of these related forms, more or less variable in shape in life and frequently crushed or otherwise distorted during burial, are often very difficult to identify.

Because this is true, a paleontologist studying a collection of sponges from the Niagaran beds of this region is frequently faced with the problem of what to do with some of his specimens which do not appear to be assignable to any described species, but which are nevertheless very close to forms already recorded from the Middle Silurian rocks of Tennessee. The writer recently found in such a collection from the Brownsville Formation of Perryville four sponges which seem to him not to belong in any described species or variety, but to be new. Two of these four specimens appear to be referable to a new species of *Palaeomanon*. The other two seem to be assignable to a new species of *Carpomanon*. Since he has not been able to find that they belong in any known species, he describes them below.

PHYLUM PORIFERA
Class Silicispongiae
Subclass Tetraxonida

Order Lithistida
Suborder Eutaxicladina
Family Astylospongidae

Palaeomanon incisum, new species

The two known examples of this species were approximately spherical in shape in life (though their fossilized remains are somewhat flattened), and were about three-fourths of an inch in diameter. They show no trace of any point of attachment at their bases. Their oscula were about one-third of an inch across, and were apparently marked on the upper surface of the sponge by a shallow depression. The preservation of the specimens does not permit us to determine whether there was a single paragastric cavity or whether there was a single aperture in the osculum or several. If there was a single paragastric cavity it must have been small; and it is more probable that there were a number of apertures in the osculum and that these led into a compound paragastric cavity. Such evidence as to the form of the interior of the sponge as is afforded by our specimens supports this view, for the interior shows only a trace of a central cavity, and the thick walls are traversed by irregularly winding canals which radiate from the center of the body. No individual spicules can be distinguished.

Our species resembles in form the sponge which Rauff* described as *Astylomanon cratera prototypum*, and which Bassler† called *Palaeomanon cratera;* but it differs from that species in being somewhat smaller (if our specimens are full-grown) and in having the furrows on the surface more deeply incised. *P. cratera*, like our species, was a member of the Brownsport Fauna; and it is possible that our form should be looked upon as a variety of *cratera*, rather than as a distinct species. Rauff (op. cit.) described a number of varieties of *cratera* from the Niagaran rocks of western Tennessee. Bassler (op. cit.) did not accept these varieties; but included them all in the one form, *cratera*. The differences by means of which Rauff distinguished his varieties were mainly differences in the form of the whole body of the sponge. Our species differs from most of his in the deeper incision of the furrows on its surface. Two of Rauff's varieties, *cratera balantium* and *cratera lecythium*, had furrows as deep as those on our specimens but had pear-shaped, not spherical, bodies.

It is possible that all of Rauff's varieties, as well as our form, should be included in *Palaeomanon cratera;* but the writer thinks it probable that the forms with deeply incised furrows should be considered as distinct from their smoother cousins. *P. cratera balantium* and *P. cratera lecythium* resemble each other sufficiently in form and in the depth of their furrows to be perhaps referable to a single species (which would then become *P. balantium*, since that was the first variety described), though *lecythium* was possibly a smaller form than *balantium*, and should therefore be considered a variety, *P. balantium lecythium.* Our species, though resembling *balantium* and *lecythium* in the depth of its furrows, is so different from those forms in the shape of its body that it is believed to deserve a distinct specific name.

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* Rauff, H. Palaeospongiologie; Palaeontographica, vol. 40 (1894), p. 315 (text-figs. A and A_1), 317, pl. 13, fig. 1.

† Bassler, R. S. Bibliographic Index of American Ordovician and Silurian Fossils, U. S. National Museum Bulletin 92 (1915), vol. 2, p. 938.

The holotype and paratype of *P. incisum* are nos. 42740 and 42741 in the paleontological collection of Princeton University.

Carpomanon verrucosum, new species

The two specimens on which this species is based are roughly spherical in form, a little less than one inch in diameter, and show no trace of an osculum. There seems to have been no paragastric cavity. Straight canals radiate from the center of the sponge to the outer surface. No individual spicules can be distinguished. Our specimens are somewhat flattened on one side, which was probably the bottom, so that their "width" is a little greater than their "height." They show no trace of any point of attachment. The entire outer surface of each of them is deeply incised by furrows, which in some cases radiate from a center but in other cases appear to have no regular arrangement, so that the outside of the sponge is cut up into many small knobs, some of which are oval in outline and radiate from a common center, but others of which are hemispherical and seem to have no definite order of position. The radiate arrangement of the furrows and knobs is found only on the "top" and "sides" of the sponge, and not on the flattened "bottom," but the knobs and furrows on the "bottom" are just as prominent as those on other parts of the surface. There are no central knobs at the points from which the ovate knobs radiate, such as are found in such other species of *Carpomanon* as *C. stellatim-sulcatum.** These central knobs appear not to be well developed in all examples of the latter species, however.

Our species is referred to the genus *Carpomanon* with some hesitation. The radiate arrangement of the ovate knobs on our specimens is not so evenly distributed over the entire surface of the sponge as is the case with most of the other species of that genus. Nevertheless our specimens appear to belong in the genus. At any rate, they seem to be more naturally assignable to it than to any other described genus.

The most noticeable feature of *Carpomanon verrucosum* is the prominence of the knobs into which its outer surface is divided. These are more convex than in any other species of *Carpomanon* known to the writer. They are comparable to the knobs on the surface of *Carpospongia conwetzi* Rauff (op. cit., p. 308; pl. 10, fig. 20). The internal structure of *Carpomanon verrucosum* seems to have been much like that of *Carpospongia* also, but that genus possessed no ovate knobs, radially arranged, and some of its species, at least, had a depression on the upper surface in the place where the osculum would naturally be. The internal structure of our specimens is similar to that of *Carpomanon stellatim-sulcatum,* as illustrated by Roemer (op. cit., pl. 1, f. 2a), and they probably belong in the same genus with that species.

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* Roemer, F. Die Silurische Fauna des Westlichen Tennessee. Breslau, 1860, p. 11, pl. 1, fig. 2.

One of our specimens (the paratype) does not have its surface so deeply incised as does the other (the holotype), and it is possible that the two are not specifically identical. The second specimen is somewhat weathered, however, and the height of the knobs between the furrows may have been thereby reduced. It appears to agree with the holotype in all other respects except that it is a little smaller.

The holotype is no. 42742, and the paratype is no. 42743, in the paleontological collection of Princeton University.

EXPLANATION OF PLATE

Fig. 1: Palaeomanon incisum, n. sp., holotype, side view, natural size.

Fig. 2: Palaeomanon incisum, n. sp., holotype, top view, natural size.

Fig. 3: Palaeomanon incisum, n. sp., paratype, cross section, natural size.

Fig. 4: Carpomanon verrucosum, n. sp., holotype, top view, natural size.

Fig. 5: Carpomanon verrucosum, n. sp., holotype, side view, natural size.

Fig. 6: Carpomanon verrucosum, n. sp., paratype, cross section, natural size.

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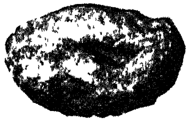

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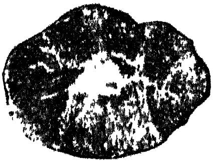

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THE OCCURRENCE OF GALENA IN CAMBRIAN LIMESTONES OF CENTRAL AND WESTERN UNITED STATES

By B. F. HOWELL, A.M., PH.D., and CHRISTINA LOCHMAN, PH.D.

The authors have had occasion to study a number of Upper Cambrian faunas from different areas in the central and western United States. In some of the collections examined in which the fossils were preserved in limestone small particles of galena, as well as pyrite and chalcopyrite, were found scattered through the limestones and at times replacing portions of the fossils. The association of galena with Cambrian faunas from widely separated regions and often from strata in which no economically important deposits are known, suggests the possibility that certain species may have been responsible for the primary concentration of the mineral.

Chemical analyses[1] of the bodies of marine invertebrates from the Tortugas have shown that a large number of minerals are normal constituents in the bodies of many members of a modern marine fauna. The minerals appear to have been concentrated by the animals from the minute quantities of metallic salts occurring in normal, uncontaminated sea water. Copper, zinc, iron and manganese were found to be present in practically all the specimens examined, but in quantities which varied markedly from species to species. More extraordinary, however, was the presence of lead in the liver of *Fasciolaria gigantea*, and of vanadium[2] in the body of the holothurian, *Sticopus möbii.*

Professor Phillips' work indicates that, in the case of these less common minerals, the mineral is concentrated only by the one species in which it is found, other closely related species not having extracted it. However, the same mineral can be used in the physiologic functions of species from widely separated phyla.[1] It is probable that, when additional specimens are analyzed, a greater number and variety of species will be found to possess the habit of concentrating large quantities of minerals in their bodies.

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[1] Phillips, Alexander H., Analytical Search for Metals in Tortugas Marine Organisms: Carnegie Inst. of Washington, Pub. No. 251, pp. 89–93, 1917.

[2] Phillips, Alexander H., A Possible Source of Vanadium in Sedimentary Rocks: Am. Jour. Sci., vol. XLVI, pp. 473–475, 1918.

The Upper Cambrian faunas with which galena has been found associated are all (in so far as it is possible to determine from the fossil remains) normal assemblages of Cambrian invertebrates—trilobites, brachiopods, pteropods, siliceous sponges, and primitive pelmatozoans and gastropods.

Faunas from the following areas have been studied:

In Missouri a large *Cedaria* fauna has been obtained by the junior author from the basal beds of the Bonneterre dolomite along the flanks of the Farmington anticline in Saint Genevieve County. From this area only one small workable galena deposit is known.[2] In the mining areas of Saint François County, the basal portion, as well as the upper beds, of the Bonneterre have been completely dolomitized, and only occasional specimens of *Dicellomus politus* (Hall) are known from them. In Saint Genevieve County the beds of the fossil horizon consist of a crystalline limestone with varying amounts of glauconite and quartz sand impurities. Where portions of these beds are locally dolomitized, fossils are absent. Small particles of galena have been found associated with this fauna at practically every fossil locality. The principal elements of the fauna are: (1) primitive cystoids and sponges; (2) inarticulate brachiopods—*Dicellomus*, *Obolus*, and *Linnarssonella;* (3) trilobites, of which *Tricrepicephalus*, *Kingstonia*, *Coosella*, *Genevievella*, *Norwoodia*, and *Millardia* are the most abundant genera; (4) a small species of *Pelagiella* and (5) *Hyolithes primordialis*.

The three faunas of the Cap Mountain formation of Texas have also been recently studied by the junior author. Small amounts of galena were observed associated with species from both the *Cedaria* and the *Crepicephalus* zones. The only galena deposit known in the Central Mineral Region occurs in a small area on Beaver and Silver Creeks[3] in greensands of the *Aphelaspis* zone. The galena has clearly undergone secondary concentration here at the Cambrian-Pre-Cambrian contact. The most important elements of the two lower faunas are: (1) inarticulate brachiopods—*Dicellomus*, *Obolus*, and *Acrotreta;* (2) trilobites—*Tricrepicephalus*, *Crepicephalus*, *Kingstonia*, *Coosia*, *Coosella*, and *Llanoaspis;* and (3) primitive sponges.

The occurrence of galena with the Upper Cambrian faunas of the Deadwood formation of the Black Hills, South Dakota, is not yet certainly known. In none of the small collections so far examined has any galena been observed. At the present time, the only definite assertion which can be made is that galena does not occur where the faunas are found in sandstone. Whether this is a primary condition characterizing faunas living in such an environment, or a secondary one caused by subsequent thorough leaching of the sandstones, is not known; nor can the authors find any published account of research on modern faunas which might throw light on this subject. Apparently a similar condition prevails in the Upper Cambrian of Wisconsin, where the section consists almost entirely of sandstone.[1]

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[1] Phillips, Alexander H., *ibid.*, p. 474.

[2] St. Clair, Stuart, The Geology of St. Genevieve County, Missouri: Mo. Bur. of Geol. and Mines, 2nd ser., vol. XXII, p. 347, 1928.

[3] Paige, Sidney, Mineral Resources of the Llano-Burnet Region, Texas: U. S. G. S. Bull. 450, pp. 75–77, 1911.

A most interesting occurrence of the association of galena and also particles of sphalerite with Upper Cambrian fossils was noted recently during a study of faunas of this age from Montana. Although this study is yet far from completion, the following important details can be offered:

1. The *Crepicephalus* fauna is present in a coarsely crystalline glauconitic limestone in the basal portion of the heavy bedded limestone of the section on Grove Creek, Carbon County, Montana. Particles of galena occur scattered through this limestone, and in several instances galena[2] replacement of specimens (namely, portions of the free cheeks of *Tricrepicephalus*) has been observed. The principal elements of this fauna are *Tricrepicephalus*, *Crepicephalus*, *Coosia*, *Kingstonia*, *Hyolithes primordialis*, and primitive sponges.
2. The *Aphelaspis* fauna, lying immediately above the *Crepicephalus* fauna in the Grove Creek section, occurs in a fine-grained, gray, crystalline limestone. Small particles of sphalerite[3] are found scattered irregularly through this limestone.

Although the above described conditions are most suggestive of the existence of a definite relationship between certain of the early Upper Cambrian faunas and the presence of galena or sphalerite in the formations in which they occur, the authors recognize the necessity of extensive investigation along many lines before the possibility can be regarded as a reasonable certainty.

Galena and also sphalerite are probably more common in certain types of sedimentary rocks than most stratigraphers realize. Both minerals are found in the Silurian waterlimes of Ulster County, New York, often intimately associated with such fossils as corals, in the visceral chambers of which galena, especially, is frequently found.

It is perhaps significant that, while glauconite is commonly present in the Upper Cambrian limestones from the central and western states, which hold galena, no phosphatic concretions have been found in those rocks. It should be noted, also, that glauconite is common in some of the Upper Cambrian sandstones of the Upper Mississippi Valley, especially in the so-called "greensands" of the Franconia and Trempealeau.

The Upper Cambrian deposits of the Upper Mississippi Valley, Missouri, Texas (in part), South Dakota, Wyoming, and Montana show clear evidence in their lithology that they accumulated for the most part very slowly in shallow marine waters. The waterlimes of New York are also known to have been formed at shallow depths. The Tortugas fauna studied by Professor Phillips was likewise a shallow water one.

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[1] The ore at Mine La Motte, Missouri, represents a secondary enrichment in dolomite lenses in the upper part of the La Motte Sandstone.

[2] Determination made by Dr. H. H. Hess, Princeton University.

[3] Microchemical determination by M. E. Cooley, Mt. Holyoke College.

It seems probable that a condition of extremely slow sedimentation in the shallower marine basins was one of the factors necessary for the primary accumulation of the galena and sphalerite, as well as for the glauconite,[1] which are found in the Upper Cambrian limestones of Missouri, Texas, and the West. Animals were undoubtedly at least partly responsible for these accumulations, but much still remains to be learned about the whole problem. The subject is one whose further investigation will almost certainly yield interesting and fruitful results.

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[1] Galliher, E. Wayne, Glauconite Genesis: Bull. Geol. Soc. Am., vol. 46, pp. 1351–1365, 1935.

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A SYNOPSIS OF THREE LECTURES ON EMOTIONS AND THE SOCIAL ORDER

(Delivered under The Richard B. Westbrook Free Lectureship, 1938)

BY FREDERICK H. LUND, A.M., PH.D.
Professor of Psychology, Temple University

LECTURE I

EMOTIONS: THEIR RELATION TO HUMAN INTERESTS AND OBJECTIVES

1. *Present Interest in Emotions:* There are a number of circumstances existing today which make this subject particularly vital. In the field of progressive education more attention is being given to the emotional life of the individual. Progressive educators believe that the emotional life of the individual should be cultivated for its own sake. A great deal of research has been carried on to study the relation between emotions and the educative process. In the past, emotions have been considered as things to be suppressed. We can now look at emotions from the positive as well as the negative side.

The atmosphere in Europe is charged with emotional implications today. There is war in the field of ideas as well as in arms. Whether we shall have peace or war depends not on armaments—they are merely symbols. What we need is intellectual and emotional disarmament.

2. *The Nature of Emotional States:* Emotions are typically identified with strong feeling or desire, widespread visceral changes, and states of disturbance or disruption of mental and physical processes. Physiologically there are only 4, 5 or 6 emotions. According to the dictionary there are 300 distinguishable emotions. The difference exists because the words describing emotions are descriptive of the social situations. In fear and anger the internal condition is the same.

3. *Emotion and Reason Contrasted:* Man is a creature of the heart rather than the head. His aims and objectives are emotionally determined. He is rational not in what he wants, but in how he gets what he wants. What is the purpose of existence except the full realization of emotions? What purpose has the human race except the perpetuation in the mind or body of that which we find agreeable? It's human nature to like to do the things we do. Fundamentally our wants are the same as those of animals.

4. *Emotions and Values:* How do values arise? Things have value because there is: (1) a need; (2) a scarcity—this is more important. We can show value by demonstrating need and the difficulty of attainment. Stimulation and restraint give value to situations. A man likes to fish because he must overcome difficulties and must wait for a catch. Fishing wouldn't be a sport if the man could get all the fish without difficulty. When is a person most in love? When there are uncertainties and when the object of the individual's affections is almost unattainable. Life would become boresome if there were no restraint of desires. Life, in order to attain its fullness, must have a technique. You must struggle for things.

5. *Emotions and Belief:* Social institutions are founded on attitudes of belief. Attitudes are established through appeals to emotions and the recognition of emotion. Belief exists in concepts which are subjective and can't be verified. It cannot exist when there is a demonstrable answer—such as in questions in mathematics or physics. Belief is the foundation of our political, moral, legal, and religious institutions. Why does belief gain high emotional value? (1) it satisfies desires; (2) in a clash of opinions—you become excited when you deal in those spheres in which you can't prove you're right. The educational system is concerned with indoctrination, its purpose is to establish prejudices. This is not wrong. Some of the finest things in life—loyalty, patriotism, and love—are based on prejudices. If you rid yourself of prejudice and bias, life would lose its fullness. Of course there are some prejudices we should get rid of, but many of them should be retained. Institutions are things for which men live. Reason does not have to be introduced to justify it, because we don't live by reason. Many people think with their feelings. This is recognized by politicians, religious leaders, attorneys, and orators who use the technique of stirring emotions. Because the instruments of propaganda are more effective than ever before, there is a threat to the institutions which we love. By virtue of our freer institutions, we in the United States lay ourselves open to other propaganda. We must protect ourselves against it by using their measures; counteract it with our own propaganda. Democracies of the world have come to the crossroads. We have a right to fortify the institutions in which we believe in order to resist.

LECTURE II

EMOTIONS: THEIR PHYSIOLOGY AND MEASUREMENT

Historical Interpretations: Traditionally the heart has been called the seat of emotions because we are more aware of cardiac changes when we are in an emotional state. In general there have been three schools in the interpretation of emotions; these are: (1) Mentalistic; (2) Dualistic, and (3) Behavioristic. The Mentalist believes that emotion is a mental state and that physiological responses are a result not a cause. The Dualist believes that the mind and body are distinct entities and that they interact. The Behaviorist places the emphasis on outward response. An emotional state with its mental and physical phases is extremely complex. No emotional state arises except as there are mental states. The mental and perceptual states initiate other physiological states and lead to overt responses and visceral changes. These visceral changes are the most important since emotion is described as a stirred-up condition of the individual, characterized by strong feeling states, and widespread, centrally aroused visceral changes.

Neural Basis of Emotions: In order to understand emotional states we must know something about the nervous system. The central nervous system is made up of the brain, brain stem, and spinal cord. Its function is to control skeletal or somatic system, providing for adjustments to external world. The autonomic system controls the vital and visceral organs, including the circulatory, digestive, and respiratory systems. Its function is to prepare the body for certain adjustments to the outside world for activities which the organism must engage in, in order to meet conditions.

The autonomic system is the master; the central nervous system, the servant. There are four distinct levels of neural activity: (1) Cortical level—these nerve centers are found right below the cranium and control the complex functions, such as learning and speech activities. (2) Sub-cortical—emotional and instinctive life have their origin in these centers. There is not much difference in structure and function of this level in all animals. (3) Somatic reflex levels: these provide for automatic adjustments to environment, such as walking. (4) Visceral reflex level: these nerve centers are responsible for the control of internal organs. From the evolutionary point of view, the visceral level is the oldest and least affected by drugs. The cortical was the last to evolve and is the least stable, as according to the principle that more recently acquired functions are less stable. The nerve centers operate in an hierarchical fashion with the cortical level exercising dominion over the sub-cortical, etc. The seat of emotions is found on the sub-cortical level in the sub-thalamus. Evidence of this is in the effect of drugs, anaesthesia, and alcohol. When the individual is in a drugged condition, the sub-cortical level is freed from the control of the cortical level and the individual becomes emotional. Another way of demonstrating the sub-thalamic origin of emotion is the removal of the tissues in this level. When this is done emotions can be no longer aroused. Also in the case of diseases which cause lesions in the fibers connecting cortical and sub-cortical levels the individual becomes extremely sensitive. This exaggerated sensitivity is caused by lack of cortical control.

The autonomic nerves, necessary for the connection between the central nervous system and outlying ganglia, are the cranial, sympathetic, and sacral. In classifying emotions with regard to their physiological components there are about four fundamental divisions. These are the Pleasant, Unpleasant, Profound, and Aesthetic. In the pleasant emotional state there is increased activity over the cranial and sacral nervous systems (these can be called "pleasure nerves"). Food and sex appetites, facilitated by the same stimuli, are in this category. In the unpleasant emotional state the impulses pass out over the sympathetic system. These are antagonistic to the cranial-sacral, and are "tension nerves." Profound emotional states involve both systems, either simultaneously or successively. Martial music, or a work like the Fifth Symphony, tends to produce profound emotional states. In this emotional state there are skin changes (erection of the hair), and a feeling of a "lump" in the throat, and a disposition to weep. In fact, weeping occurs only when both systems are involved—in the mixed emotional state. Whether a person "weeps for joy," or "weeps for sorrow," depends on the social situation. The individual weeps in conditions of relief after tension or the realization that the "cloud has a silver lining" feeling. When the individual weeps in anger, it is because of the feeling of self-pity, "poor me" attitude. Both systems are also involved in sex. The aesthetic emotion has little or nothing to do with the autonomic system. The neural and physiological states of the nervous system are important in this emotion. Readiness to respond has great importance in the aesthetic emotions. In the dance the movements occur in rhythmic fashion and natural patterns. The movements are pleasing and have aesthetic value because any reaction is pleasing if the body is in readiness to make it. The individual's enjoyment of music depends on how his nervous system is organized either through heredity or experience.

Purpose and Utility of Emotions: Emotional changes have their origin in biological carry-overs from primitiveness. The internal changes provide for more effective adjustments to external conditions. Through changes in blood distribution, coagulation, and many other physiological changes, the body is mobilized for reaction.

LECTURE III

Emotions: Their Development and Control

Classification of Emotional and Bodily Changes: (1) Circulatory: a. heart activity, rate and force of beat; b. blood vessels, constriction and dilation, and changes in distribution; c. blood content, increase in oxygen and glycogen. (2) Respiratory: rate and volume of breathing. (3) Gastro-intestinal: a. muscular activity (peristalsis), increased under pleasant stimulation, decreased under unpleasant; b. secretion, increased under pleasant stimulation, decreased under unpleasant. (4) Sexual: dilation of blood within the organs and constriction of the blood vessels leading away from them. (5) Electrical: change in the resistance to current—resistance is lowered when the individual is in an emotional state. The galvanometer is used to measure emotions (interesting results recorded in theatres showed that children react more emotionally to movies than do adults). The lie-detector is nothing more than a galvanometer and is really an emotion detector.

Hereditary or native factors: The facial segment: the face is highly mobile, and is the best indicator of an emotional state because it is really a segment of the wider distribution of nerve impulses set up when the individual is in an emotional state. Evidences of hereditary aspects are: (1) infants show patterns of response, such as the scowl and smile. (2) Universality—different races have the same facial reactions. (3) Complete control not possible. Affirmative nodding movements and negative shaking movements of the head have their origin in the infant's attempts at food-getting. These gestures relating to food have been carried over into the social situation. Other expressions and gestures have primitive origins, such as the baring of the teeth in a sneer, the lowering of the eyebrows (primitively to protect the eyes) in hate, and raising the eyebrows in astonishment.

Development of Emotions: The age factors in the development of emotions are concerned with changes in organic states and glandular secretions. The intensity and type of emotions and the objects which arouse those emotions vary with age. But the development of emotional life does not relate to the internal state but to a process of conditioning. Conditioning means that objects gain emotional value if they are present when the individual is in an emotional state. Thus experience and training determine the objects which shall have emotional value. Conditioning may be implicit or explicit. The process of "falling in love" is largely implicit conditioning in the absence of the loved one.

Abnormal emotions are not inherited—they are developed. Shell shock occurs when the soldier is subjected to prolonged fear and tension conditions until cortical control is eventually lost. "Losing your head" means that the cortical influence is gone. In hysteria the adult responds to a situation like a child would respond. Nervous breakdowns are really emotional breakdowns. They involve the loss of cortical control and develop after prolonged periods of tension and worry. Consequently the cure for a nervous breakdown is to get the individual away from emotional stimuli.

Emotional maturity is reflected in the appropriate emotion and its appropriate use. Typical characteristics of emotional maturity are tolerance to pain and discomfort, restraint, poise, and ability to wait for rewards.

Control of Emotions: In considering the control of emotions there are both the negative and positive methods. The aim is to give emotions the proper direction. Physiological conditions which impair control are toxic conditions in the body, and the impairment of higher nerve centers through fatigue, overwork, tension, worry, use of drugs or alcohol.

Another means of control is to eliminate unpleasant emotions through reconditioning. For example, if you are needlessly afraid of something, think of that "fear object" when you are in a pleasant emotional state. It will then gain pleasant emotional value.

Relief from an emotional state is not obtained through emotional release. Experiments have proved that "getting it out of your system" through emotional outbursts increases rather than relieves the emotional state. Cats when bound and placed in a cage and then confronted with a barking dog take less time to recover from their fear than do cats that are free to move about and make overt responses. This resulted in Cannon's theory that if you exercise restraint, the intensity of emotion is reduced. When the individual makes overt and appropriate expression when he is in a state of fear and anger, the fear and anger states are increased, not decreased.

In considering personality traits the most important thing to remember is that characteristics of personality are emotional in character. Personality traits relate directly to glandular balance. In the case of the male the adrenal gland is more active and as a consequence the male of the species is more aggressive. These sex differences in personality are observable far down in the scale. We are all changing selves, we are all changing personalities, because we are changing internally. Conflict is natural in a being subject to changing internal states. This is not undesirable—the most interesting people are the temperamental ones.

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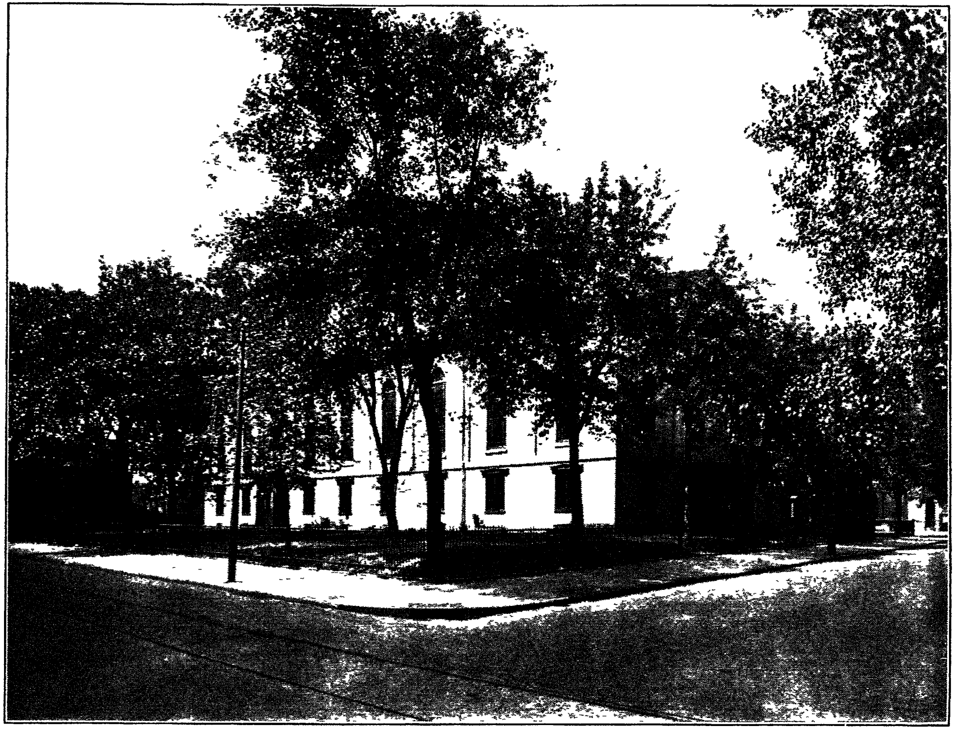

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John Wagner, Jr., B.S., C.E.

Department of Biology

Samuel C. Schmucker, Ph.D., Sc.D., *Zoology*
George B. Kaiser, *Botany*

Department of Physical Science

Leslie B. Seely, B.A., Pd.D., *Physics*
David W. Horn, Ph.D., *Inorganic and Physical Chemistry*
Ivor Griffith, Ph.M., Sc.D., *Organic Chemistry*

Department of Geology and Paleontology

Benjamin F. Howell, A.M., Ph.D.

Carl Boyer, *Director*

HISTORY

The Wagner Free Institute of Science was founded in 1847 by William Wagner, a citizen of Philadelphia.

In his early life William Wagner became associated with Stephen Girard in the extension of Girard's mercantile business. While in Girard's employ he had the opportunity to visit foreign countries, and being interested in scientific pursuits, he made a study of scientific institutions abroad and collected natural history specimens which afterward formed the nucleus for the collections in the museum of the Institute.

The Institute, itself, had its inception in a series of free lectures delivered by Professor Wagner in his home. These lectures, begun in 1847, were continued until 1855 when the Institute was incorporated by act of legislature.

A large measure of credit is due Mrs. Louisa Binney Wagner, Professor Wagner's wife, for sympathy, understanding and active coöperation in the early days of the founding of the Institute.

In 1855 a faculty was appointed and the work was continued in a new location at 13th and Spring Garden Streets, the City of Philadelphia giving permission for the use of Commissioners' Hall. Some years later Professor Wagner decided to erect a building on the present site at Seventeenth Street and Montgomery Avenue. This building was completed in 1865 and occupied immediately.

William Wagner died in 1885 and the management of the Institute was transferred to a Board of Trustees.

In 1901 a wing was added to the building for the use of a branch of the Free Library of Philadelphia.

INSTRUCTION

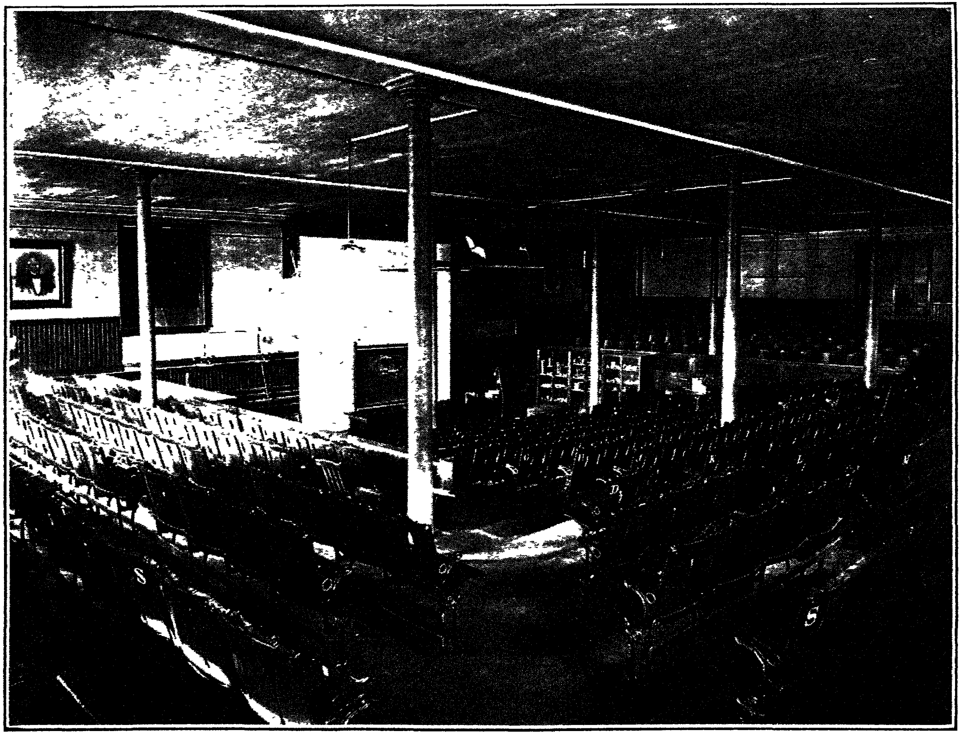
LECTURES AND CLASS-WORK

Instruction at the Wagner Free Institute of Science is conducted by means of lectures supplemented by class work. There are no tuition fees.

Persons may attend lectures without registering for the classes if they so desire. Those registering for the classes are required to hand in a weekly paper and are admitted to an examination at the end of the term. Those persons successfully passing the examination are awarded certificates for the year's work.

There are seven courses of scientific lectures covering a period of fourteen weeks each for four years. On the successful completion of four years' work a Full Term Certificate is awarded.

The closing of each lecture season is marked by Commencement Exercises.



Auditorium

Museum

MUSEUM

The Institute maintains a natural history museum containing more than 21,000 specimens illustrating the various branches of natural science.

The collections are arranged especially for study. The museum is open to visitors on Wednesday and Saturday afternoons from 2 P.M. until 5 P.M., except legal holidays.

On each Monday evening at 7 P.M., from September to May, a "Museum Talk" is delivered in the museum, the speaker using the specimens in the museum to illustrate the lecture.

Teachers and students desiring to use the museum for special studies will be admitted upon application at the office.

LIBRARIES

The Reference Library of the Institute contains over 25,000 bound volumes and approximately 150,000 pamphlets on scientific subjects, classified and arranged for ready reference. There are also many foreign and domestic periodicals on file. The library is open to the public as well as to students from 10 A.M. to 9 P.M. daily, except Sunday.

The Free Library of Philadelphia maintains a branch library in the building, known as the Wagner Institute Branch, from which books may be taken out under the rules of the Free Library.

PUBLICATIONS

The publications of the Institute consist of three series:

Transactions: begun in 1885 and discontinued in 1927.

Publications: succeeding the Transactions. These Publications are issued at irregular intervals.

Bulletin: issued quarterly.

SPECIAL LECTURES

WESTBROOK FREE LECTURESHIP

The Westbrook Free Lectureship is supported by the income from an endowment provided by Dr. Richard Brodhead Westbrook and his wife, Dr. Henrietta Payne Westbrook. The lectureship was established in 1912 and provides for one course of lectures each year. These lectures cover a wide range of topics and a list of those so far given may be found on page 29.

FANNIE FRANK LEFFMANN MEMORIAL LECTURESHIP

The income of a fund given by Dr. Henry Leffmann is applied to occasional special lectures under the Memorial Lectureship. These lectures are popular in character.

The *Philadelphia Natural History Society* is affiliated with the Institute and holds meetings on the third Thursday of each month from October to May.

RESEARCH

The Institute has carried on research work since 1885 in various departments of science. Results of research have been published from time to time in the Transactions, Publications and Bulletin.

The Institute is also the recipient of the income from two funds established by Dr. Henry Leffmann. This income is devoted to research in chemistry.

CERTIFICATES AWARDED AT CLOSING EXERCISES, MAY 18, 1938

FULL TERM CERTIFICATES

BOTANY

Ina Bein
Edward P. Frey
Florence H. Gillin
James R. Gillin
Eileen E. Hand
Louis E. Hand
William G. Ramsey

INORGANIC CHEMISTRY

Louis Moyd
Charles F. Summers

ORGANIC CHEMISTRY

William G. Ramsey
Otto J. Schoppe
George F. Stauffer
Charles F. Summers

ENGINEERING

Charles F. Summers
Arthur T. Tigue

ZOOLOGY

Arthur S. Adams
Ina Bein
Beecher Finch
Martha Finch
Gordon Hill
John G. Hope
Lelia M. Stauffer
Charles F. Summers
Helen B. Vail

GEOLOGY

Beecher Finch
Louis Moyd
Charles F. Summers
Helen B. Vail

PHYSICS

Myles Brazill
Beecher Finch
Louis Moyd
Charles F. Summers

1937-1938 CERTIFICATES

BOTANY 3

Ina Bein
Dorothy M. Burnett
Adon E. Burnham
Dorothy R. Doyle
Francis H. Doyle
Nathan Fitelson
Edward P. Frey
Oscar F. E. Gentieu
Florence H. Gillin
James R. Gillin
Eileen E. Hand
Louis E. Hand
John F. Hardecker
E. Frances Hervey
Daniel Hofheimer
John G. Hope
John J. Kane
Edith H. Lee
Harriette A. Lyon
Carroll R. McDonnell
Lilla P. Murdoch
Lola I. Poppleton
William G. Ramsey
Edith G. Rice
Mary H. B. Schrack
Helen B. Vail

INORGANIC CHEMISTRY 1

William E. Albright
Charles H. Angstadt
Melvin L. Erben
Robert J. Gill
Leonard Miller
Rose Millstein
Sophie Millstein
Louis Moyd
Frank Rush
Robert Serviss
Samuel Shober
Harry Silver
Charles F. Summers
Joseph Sussna
Raymond S. Whitehead

ORGANIC CHEMISTRY 1

William E. Albright
Myles Brazill
Joseph Brown
Russell Bruck
Melvin L. Erben
William J. Gane
John Grava
Harold Krelove
Ralph M. Olson
William G. Ramsey
Otto J. Schoppe
Samuel Shober
Harry Silver
George F. Stauffer
Thomas L. Strong
Charles F. Summers
Raymond S. Whitehead

ENGINEERING 3

John M. Bley
Bert Block
Joseph P. Burke
Bernard Dunn
Joseph S. Ferringo
Beecher Finch
Oscar F. E. Gentieu
Ralph A. Hafner
Louis L. Langford
John F. McDevitt
L. Gilbert Obermiller
J. Francis Sibre
Charles F. Summers
Arthur T. Tigue

ZOOLOGY 2

Arthur S. Adams
Aaron Anton
Elizabeth Anton
Elaine L. Bailey
Ina Bein
John Berninger
Kitson A. Broadbelt
Stephen Daly
Melvin L. Erben
Beecher Finch
Martha Finch
Elwood J. Fisher
Paul A. Fisher
Elva K. Fromuth
Eileen E. Hand
John F. Hardecker
Richard C. Hayward
Gordon Hill
John G. Hope
Fannie S. Kirshner
Harriette A. Lyon
Blanche Manning
Carroll R. McDonnell
Ralph M. Olson
Ann Sayen
Samuel Shober
Mildred N. Sholl
Lelia M. Stauffer
Thomas L. Strong
Charles F. Summers
Helen B. Vail

GEOLOGY 3

Ina Bein
John Berninger
Beecher Finch
Paul A. Fisher
Arthur Guest
Edward Herrera
Emanuel Hocking
Blanche Manning
Louis Moyd
Albert H. Petri
Samuel Shober
Mildred N. Sholl
Charles F. Summers
Helen B. Vail

PHYSICS 4

John Berninger
Walter J. Bieri
Myles Brazill
Hildegarde E. Ernst
Fay M. Felsher
Beecher Finch
Paul A. Fisher
Stephen F. Gumrot
Edwin Hahn, Jr.
Thomas C. Hall
Max A. Hanker
Louis Moyd
David Olshansky
Samuel Shober
Charles F. Summers

FACULTY

SAMUEL CHRISTIAN SCHMUCKER

A.M., M.S., Sc.D., Muhlenberg College.
Ph.D., University of Pennsylvania.
Professor of Biological Sciences, State Teachers College, West Chester, Pa., 1895–1923.
Science Department, Summer Schools, Chautauqua, N. Y., 1906–1928.
Lecturer on Biology, Brooklyn Institute of Arts and Sciences, 1905–1933.
Professor of Botany, Wagner Free Institute of Science, 1908–1926.
Professor of Zoology, Wagner Free Institute of Science, 1926 to date.
Dean of the Faculty.
Author of
"The Study of Nature." (Lippincott Co., Philadelphia.)
"The Meaning of Evolution." (Macmillan Co., N. Y.)
"Man's Life on Earth." (Macmillan Co., N. Y.)
"Heredity and Parenthood." (Macmillan Co., N. Y.)

JOHN WAGNER, Jr.

B.S. in C.E. 1913, University of Pennsylvania.
C.E. 1920, University of Pennsylvania.
Assoc. M., Am. Soc. C. E.
1913–1916, Draftsman, Phoenix Bridge Company.
1916–1921, Office of Engineering Bridges and Buildings, Pennsylvania Railroad, including two years' service with the Army as First Lieut. and Captain in the Cavalry.
1921–1926, Assistant Supervisor Track, Reading Company.
1926–1928, Supervisor Track, Reading Company.
1928–1936, Industrial Agent, Reading Company.
1936 to date, Assistant General Freight Agent, Reading Company.
Professor of Engineering, Wagner Free Institute of Science, 1926 to date.

LESLIE BIRCHARD SEELY

Graduate, State Normal School, Bloomsburg, Pa.
Taught school, Luzerne and Snyder Counties, Pa.
Assistant instructor in physics and chemistry, Bloomsburg, 1899–1902.
Graduate, Haverford College, 1905.
Head Master, Friends Institute, Chappaqua, N. Y., 1905.
Instructor in physics, Northeast High School, Philadelphia, 1906–1915.
Head of Science Department, Germantown High School, 1915–1923.
Principal, Roxborough High School, 1923–1924.
Principal, Germantown High School, 1924 to date.
Graduate courses, University of Pennsylvania and Brooklyn Institute, 1906–1910.
Honorary degree of Doctor of Pedagogy, Ursinus College, 1926.
Professor of Physics, Wagner Free Institute of Science, 1912 to date.
Publications:
"Description of Two New Distomes," Biological Bulletin, Lancaster, Pa., 1906.
"Ether Waves and the Messages They Bring," Transactions of the Wagner Free Institute of Science.
"The Physics of the Three-electrode Bulb," Transactions of the Wagner Free Institute of Science.

DAVID WILBUR HORN

A.B., Dickinson College, 1897.
A.M., Dickinson College, 1898.
Ph.D., Johns Hopkins University, 1900.
Assistant in Chemistry, Johns Hopkins University, 1900–1901.
Associate and Associate Professor of Chemistry, Bryn Mawr College, 1901–1907.
Lecturer in Hygiene, Hahnemann Medical College, 1911 to date.
Head of Pre-Medical School of Science, Hahnemann Medical College, 1916–1921.
Professor of Physics and Physical Chemistry, Philadelphia College of Pharmacy and Science, 1921–1937.
Professor of Inorganic and Physical Chemistry, Wagner Free Institute of Science, 1911 to date.
Chairman of Philadelphia Section of American Chemical Society, 1904 and 1905.
Fellow of American Association for the Advancement of Science.
Fellow of the Royal Society of Arts of London.

IVOR GRIFFITH

Early education at the Bethesda Academy, Wales, and came to America in 1907.
P.D., Philadelphia College of Pharmacy and Science, 1912.
Ph.M., Philadelphia College of Pharmacy and Science, 1921.
Sc.D. (Hon.), Bucknell, 1934.
Director of Research, John B. Stetson Company, 1925 to date.
Research Adviser, McNeil Laboratories, Philadelphia, 1937 to date.
Director of Laboratories, Stetson Hospital, 1920 to date.
Editor, American Journal of Pharmacy, 1921 to date.
Associate Professor of Pharmacy, Philadelphia College of Pharmacy and Science 1914 to date.
Dean, Philadelphia College of Pharmacy and Science, 1938 to date.
Professor of Organic Chemistry, Wagner Free Institute of Science, 1926 to date.
Secretary of the Faculty of Wagner Free Institute of Science.
Fellow of the American Institute of Chemists.
Fellow of the American Association for the Advancement of Science.
Fellow of the Pennsylvania Academy of Science.
Member American Chemical Society.
Member American Pharmaceutical Association.
Publications:
"Recent Remedies," 1926 (revised 1928). International Publications, N. Y.
"Popular Science Lectures" (Editor) (thirteen volumes). Phila. College Pharmacy and Science, Phila.
Science Miscellany. International Printing Company, Phila.
U. S. Dispensatory (Collab. Editor). Lippincott, Phila.
Formula Book, A. Ph. A. (Editor). Lippincott, Phila.
Contributor to current chemical, pharmaceutical and medical literature.

GEORGE BRINGHURST KAISER

Educated in private schools.
Graduate, Franklin School.
After graduation spent several years in intensive botanical study and field work in northeastern United States.
Secretary of the Botanical Society of Pennsylvania for seven years and leader of its field trips.
Professor of Botany, Wagner Free Institute of Science, 1927 to date.
Curator, Moss Herbarium, Sullivant Moss Society.
Treasurer, Delaware Valley Naturalists' Union.
Member, Academy of Natural Sciences.

BENJAMIN FRANKLIN HOWELL

B.S., A.M., Ph.D., Princeton University.
Associate Professor of Geology and Paleontology, Princeton University.
Professor of Geology and Paleontology, Wagner Free Institute of Science, 1927 to date.
Curator of Invertebrate Paleontology and Stratigraphy in Princeton University.
Fellow of the Paleontological Society.
Secretary of the Paleontological Society.
Fellow of the Geological Society of America.
Fellow of the American Association for the Advancement of Science.
Member of the Palaeontologische Gesellschaft.
Associate Member of the Society of Economic Paleontologists and Mineralogists.
Member of the Committee on Micropaleontology of the National Research Council.
Chairman of Cambrian Subcommittee of U. S. National Research Council Committee on Stratigraphy.
Secretary of the Organization Committee of the International Paleontological Union.
Editor of the section of General Paleozoology of *Biological Abstracts.*
American Editor of *Palaeontologisches Zentralblatt.*
Specializes in Cambrian Paleontology and Geology.
Associated with U. S. Geological Survey, the U. S. National Museum, Geological Survey of Canada, Canadian National Museum, Geological Survey of Vermont, Geological Survey of Montana, Colorado School of Mines, as a consulting paleontologist and research associate.

REGULAR LECTURES, SESSION OF 1938–1939

BOTANY 4

PROFESSOR KAISER

Physiology and Ecology

Lectures begin at 8 P. M.

1. Monday, September 12.
   How plants get their food from the necessary elements. The physics and chemistry of plant life. Cardinal points of growth.
2. Monday, September 19.
   How plants get carbon from the air. The necessity of leaf green in maintaining life upon the earth. The story of starch and its derivatives and of enzymes and their uses.
3. Monday, September 26.
   How plants get their nitrogen. How parasites, saprophytes and symbionts live. The helpful nitro-bacteria. The story of flesh-eating plants.
4. Monday, October 3.
   How plants breathe. Respiration contrasted with photosynthesis. How breathing in plants produces heat and light. Details of growth and development and the great age of trees.
5. Monday, October 10.
   How plants move from internal causes. Movements of vital fluid within walled cells and of diatoms and desmids. How floral clocks and calendars may be made.
6. Monday, October 17.
   How plants move from external causes. The stimuli of light, gravity and other forces that influence plants. The sleep of plants.
7. Monday, October 24.
   How plants increase and multiply. Vegetative and sexual reproduction. How pollen is borne by wind, insects, birds, snails, bats and water. How seeds are scattered to perpetuate the species.
8. Monday, October 31.
   How plants are distributed in relation to their surroundings. The zones of the earth and their vegetation. The part that water plays in determining floras. How plants succeed each other in geologic time.
9. Monday, November 7.
   How plants are distributed in North America. Plants of the coastal plain, sand dune and pine barren. The gulf states, lake shore and stream valley, prairie, forest, grassland and desert. The Pacific Coast.
10. Monday, November 14.
    How plants are distributed in Europe and the Alps. The British Isles, Mediterranean region, Asia, Japan, the Himalayas, Russia and the Atlantic Islands.
11. Monday, November 21.
    How plants are distributed in the tropics of the Old World. The heart of Africa and continental Asia, "the cradle of the human race." Notable plants and delicious fruits of Malaya and the South Sea Islands.
12. Monday, November 28.
    How plants are distributed in the tropics of the New World. Characteristic species of Mexico, Central America, the West Indies, Trinidad and the wilds of South America. The virgin forest of Brazil.

13. Monday, December 5.

    How plants are distributed in South Africa, Australia, New Zealand, Fuegia, and Chile. The region of Cape Horn and Gondwana Land of ancient geologic time.

14. Monday, December 12.

    How man has influenced the distribution of plants and the course of evolution. His destructive and constructive forces. Brief considerations of plant breeding, natural selection, mutation, heredity and hybridization. Recapitulation.

Field Trip

The class in Botany will be conducted on a field trip under the leadership of Professor Kaiser. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

INORGANIC CHEMISTRY 2

PROFESSOR HORN

Descriptive Chemistry

Lectures begin at 7.45 P. M.*

1. Tuesday, September 13.

    Chlorine. Occurrence, preparation, properties. Faraday's liquefaction of it. Bleaching power. Powerful germicidal action. Chloramines. Disinfection of drinking water and of swimming pools. Tests for active chlorine, for ionized chlorine.

2. Tuesday, September 20.

    Chlorine Compounds. The many valences of chlorine. Oxygen acids and acids without oxygen. The hydrogen ion and the pH values in determining acidity. Double halides.

3. Tuesday, September 27.

    Bromine, Iodine, and Fluorine. Occurrence, preparation, properties. General chemistry of the halogen family. The halogen acids. The outer orbit of the halogen atoms. Perhalides. Binary compounds of halogen with halogen.

4. Tuesday, October 4.

    Physical-Chemical Views. The kinetic theory of chemical action. The action of stimulants—catalysts. The effects of temperature and pressure upon chemical equilibria. LeChatelier's Theorem.

5. Tuesday, October 11.

    Sulphur. Occurrence, preparation, properties. Allotropic forms. Amorphous sulphur and colloidal sulphur. The Phase Rule diagram for sulphur. Transition Points. Sulphur halides. Thionyl halides. Sulphuryl halides.

6. Tuesday, October 18.

    Sulphur Trioxide. Preparation, properties, uses. Catalysis on the commercial scale—manufacture of sulphuric acid. Permonosulphates and perdisulphates. Thiosulphates and other thio salts. Sulphurous acid and desmotropism.

7. Tuesday, October 25.

    Selenium, Molybdenum, and Vanadium. Occurrence and extraction of selenium. Chemical similarity of selenium and sulphur. The photosensitivity of selenium. Occurrence and extraction of molybdenum. The poly-acids of molybdenum. Use of molybdic acid in phosphate analysis.

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* Please note the hour.

Occurrence of vanadium. The vanadium cycle. Alloys of vanadium and of molybdenum.

8. Tuesday, November 1.

   Nitrogen. The nitrogen cycle. The fixation of nitrogen by plants. Commercial fixation of nitrogen as ammonia, as oxides of nitrogen, as cyanamide. The nitrogen values in water analysis. Ammonia. Hydrazine. Hydrazoic acid. Nitrides.

9. Tuesday, November 8.

   The Atmosphere. The composition of the troposphere and stratosphere. The noble gases, their discovery, preparation, and uses. Vitiated air. Air conditioning.

10. Tuesday, November 15.

    Oxides of Nitrogen. The Law of Multiple Proportions. Hydrates of the oxides of nitrogen. Nitric acid, nitrous acid, and hyponitrous acids. Hydroxylamine. Nitrogen halides.

11. Tuesday, November 22.

    Phosphorus. Occurrence, preparation and properties. Allotropic forms. Phosphorus poisoning. Matches. The chlorides of phosphorus and the test for hydroxyl.

12. Tuesday, November 29.

    Oxides of Phosphorus. Normal, ortho-, meta-, and pyro-phosphoric acids. Phosphate fertilizers. Metaphosphates as detergents. The phosphomolybdates, and ammonium magnesium phosphate in analysis. Microcosmic salt in analysis. Phosphoric anhydride as a drying agent, and the chemical behavior of substances dried with it.

13. Tuesday, December 6.

    Arsenic and Boron. Chemical similarity of arsenic to phosphorus. What is a metalloid? Allotropic forms of arsenic. Arsenious and arsenic oxides. Arsenates of lead and of copper as insecticides. The sulphides of arsenic in nature and in the analytical laboratory. Arsine and the arsenic mirror. Occurrence of boron. Preparation of boron compounds. Boron and borides. Normal, meta-, and pyro-borates. Perborates as cleaning agents. Tests for boric acid.

14. Tuesday, December 13.

    Beryllium. Scandium, Gallium, and Germanium. Indium. Chemical comparison of beryllium with boron. Beryllium vs. glucinum. The beryl. Physical and chemical properties of beryllium. Mendeleeff's remarkable predictions of scandium, gallium, and germanium. The general plan followed in such predictions. Moseley's contribution to the knowledge of periodicity among the elements. The atomic number vs. the atomic weight. The problem of the atomic weight of indium. The Law of Isomorphism and the Law of Atomic Heats. The valence and the equivalent of an element.

ORGANIC CHEMISTRY 2

PROFESSOR GRIFFITH

Carbohydrates, Fats, Oils and Waxes

Lectures begin at 8 P. M.

1. Wednesday, September 14.

   Cellulose—At Home in Plant Structures. Its nature and chemical behavior.

2. Wednesday, September 21.

   Cellulose in Service. Texts and Textiles. Paper, parchment, cotton, linen, ramie, cork, coir, kapok, etc.

3. Wednesday, September 28.
   Chemicalized Cellulose. Demure (rayon, celanese) and devil (guncotton).
4. Wednesday, October 5.
   Starch—From the Storehouses of the Energy-Binders. Its nature, distribution and chemical eccentricities.

   Wednesday, October 12. No lecture.
5. Wednesday, October 19.
   Starch (Concluded). Physical properties of starch. Its role in plant and animal metabolism.
6. Wednesday, October 26.
   The Sugars. Occurrence in nature. Physical and chemical family traits. The sweet quartette—sucrose, lactose, dextrose and maltose.
7. Wednesday, November 2.
   Oils, Fats and Waxes. Proximate principles. Fixed oils and volatile oils. Oils that will—and oils that will not—saponify. Hydrogenated oils.
8. Wednesday, November 9.
   Oils, Fats and Waxes (Continued). General properties, origins. Preparation. Uses.
9. Wednesday, November 16.
   The Non-Drying Oils. Cottonseed, olive, almond, peanut, corn, castor, etc.
10. Wednesday, November 23.
    The Drying Oils. Linseed, hemp, poppyseed, soya, tung, fish oils, etc.
11. Wednesday, November 30.
    Fats and Waxes, Vegetable and Animal. Cacao butter, palm oil, lard, tallow and wool fat, beeswax, carnauba wax, etc.
12. Wednesday, December 7.
    Soaps. Saponification, composition and classification of soaps. Soap hokum.
13. Wednesday, December 14.
    Milk and Its Ilk. Butter, cheese, cream, etc. Oleomargarine and butter substitutes. Household tests and legal standards.
14. Wednesday, December 21.
    Milk and Its Ilk (Concluded). Milk and metabolism. Casein and casein products. Billiard balls and bureaus made of milk.

ENGINEERING 4

PROFESSOR WAGNER

Water Supply, Sewers, Canals, Rivers and Harbors

Lectures begin at 7.45 P. M.*

1. Friday, September 16.
   Hydrography. Water surveys of all kinds. Soundings. Current meters. Discharge of streams.
2. Friday, September 23.
   Water Supply. Water and its impurities. Analysis—chemical and biologic. Interpretation of analysis.

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* Please note the hour.

3. Friday, September 30.
   Water Supply (Continued). Sources of water. Consumption. Storage reservoirs.
4. Friday, October 7.
   Water Supply (Continued). Construction of reservoirs and dams of earth and masonry. Distributing systems. Aqueducts. Pipes.
5. Friday, October 14.
   Water Supply (Continued). Purification. Distilling. Boiling. Disinfection. Sedimentation. Filtration. Softening. Straining.
6. Friday, October 21.
   Water Supply (Concluded). Rapid and slow sand filters—their design and construction. Reduction of typhoid by filtration.
7. Friday, October 28.
   Sewers. Definitions. Sewerage systems. Requirements of a good system.
8. Friday, November 4.
   Sewers (Continued). Location. Determination of amount of sewage and storm water. Formulae.
9. Friday, November 11.
   Sewers (Continued). Size. Construction. Excavation and refilling.
10. Friday, November 18.
    Sewers (Concluded). Disposition. Processes for purification. Disposal of sludge.
11. Friday, November 25.
    Canals. Classification. History. Cross section. Water supply. Reservoirs. Feeders.
12. Friday, December 2.
    Canals (Concluded). Levels. Locks. Locomotion. Ship canals.
13. Friday, December 9.
    Rivers. Natural features. Protection of banks. Bars. Inundations. Regulation. Slack water navigation.
14. Friday, December 16.
    Harbors. Roadsteads. Harbors, natural and artificial. Dikes. Sea walls. Breakwaters.

ZOOLOGY 3

PROFESSOR SCHMUCKER

Man: His Origin, Development and Structure

Lectures begin at 8 P. M.

I. Man's Evolution

1. Monday, January 2.
   Man's Nearest Kin. The great apes. Transition forms in Java and South Africa. The Piltdown fragments. The eoliths, man's earliest tools.
2. Monday, January 9.
   Low Brow Man. The Heidelberg jaw. Neanderthal man, the first well-known type. Growth in the quality of his tools.
3. Monday, January 16.
   High Brow Man. The old man of Cro-Magnon. Tools of many types. The outburst of art.

4. Monday, January 23.
   Neolithic Man Goes Modern. Domestic animals, cultivated plants, village life and trade develop. Polished stone weapons, later replaced by bronze and iron.
5. Monday, January 30.
   The Races of To-day. All are of one species. The development of the three color types. Their migrations.
6. Monday, February 6.
   Our American Population. Three European types of whites came over. They found the red man, and imported the black. The yellow man comes in much later.

Monday, February 13. No lecture.

II. The Development of the Individual

7. Monday, February 20.
   Before Birth and during Infancy. The joining sex cells. Climbing the family tree. The detachment from the mother. Early life.
8. Monday, February 27.
   Man and Woman. Endocrine glands and their hormones. The secondary sex characters. The mental differences.
9. Monday, March 6.
   Life at High Tide. In tune with nature. The enemies: heat, cold and dampness; infections and immunity; the defective, delinquent, and the rival. Race hatred and patriotism.
10. Monday, March 13.
    Approaching the End. Increasing expectancy with little increase in the life span. Heart, kidney and cancer. Is there a future life?

III. Man's Structure

11. Monday, March 20.
    Our Inner Machinery. The levers and the motors. The chemical contributions. The directing organs.
12. Monday, March 27.
    Gathering and Using Energy. Sun power stored in food. Building food into body parts. Using the energy. Discarding the wastes.
13. Monday, April 3.
    The Brain and its Servants. The sense organs and their contributions. Acting on the news. The main office and its branch offices.
14. Monday, April 10
    What is Disease? Malformation in development. Misuse of our powers. Mechanical injury. Invading organisms. Immunity, natural and acquired.

Field Trip

The class in Zoology will be conducted on a field trip under the leadership of Professor Schmucker. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

GEOLOGY 4

PROFESSOR HOWELL

Historical Geology

Lectures begin at 7.45 P. M.*

1. Tuesday, January 3.
   Old Mother Earth's Autobiography. How she wrote her fascinating diary on enduring leaves of stone.
2. Tuesday, January 10.
   The First Chapter of the Great Stone Book. The difficulty we have in reading its faded record.
3. Tuesday, January 17.
   The Writing Becomes Easier to Read. How we are now learning how to decipher the second chapter.
4. Tuesday, January 24.
   Pictures Are Added to Make the Story More Vivid. The Cambrian chapter has fossils for illustrations.
5. Tuesday, January 31.
   The Pictures Become Better and More Numerous. The more heavily armored Ordovician animals leave a better record in the rocks.
6. Tuesday, February 7.
   The Events of Silurian and Devonian Times. How some ambitious water-dwellers ventured out onto the dry lands.
7. Tuesday, February 14.
   The Growth of the Great Coal Forests of the Carboniferous Period. How the coal which we burn today was formed.
8. Tuesday, February 21.
   The Hard Times of the Permian Ice Age. How the cold climate of those days caused the extinction of many kinds of plants and animals.
9. Tuesday, February 28.
   Good Times Come Again and the Reptiles Spread Over the Earth. The rise of the dinosaurs in the Triassic and Jurassic periods.
10. Tuesday, March 7.
    The Cretaceous Period and the End of the Age of Reptiles. The flowering plants appear as the dinosaurs disappear from the world.
11. Tuesday, March 14.
    The Age of Mammals and Birds Begins. The mammals replace the reptiles as the dominant animals of the lands.
12. Tuesday, March 21.
    The Golden Age of Mammals. How the mammals had their heyday in Late Tertiary times.
13. Tuesday, March 28.
    Hard Times Come Again. The great Pleistocene Ice Age and its effect on continental animals and plants.
14. Tuesday, April 4.
    The Rise of Man. How men came to inherit the earth.

Field Trip

The class in Geology will be conducted on a field trip under the leadership of Professor Howell. Owing to the difficulty of arranging a schedule in advance, details of time and place will be announced later.

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* Please note the hour.

PHYSICS 1

PROFESSOR SEELY

Properties of Matter, Measurement, and Mechanics

Lectures begin at 8 P. M.

1. Wednesday, January 4.
   Man's efforts to understand the material universe. Properties of Matter. Measurement. States of Matter.
2. Wednesday, January 11.
   Motion is universal. How objects without power to move themselves are made to move. How men study, classify, and measure motion.
3. Wednesday, January 18.
   A simple fundamental law of motion. Newton's Laws of Motion. Momentum, Acceleration and Inertia.
4. Wednesday, January 25.
   Motion not always simple. Complicated motions may be simplified for study. Whirling and spiral motions.
5. Wednesday, February 1.
   How work gets done and is measured. Energy never created or destroyed.
6. Wednesday, February 8.
   A great man thinks about falling bodies. Newton's Law of Gravitation. Weight, equilibrium and stability.
7. Wednesday, February 15.
   How the motion of falling bodies is measured. Paths of projectiles. The pendulum.

   Wednesday, February 22. No lecture.
8. Wednesday, March 1.
   Man's intelligence leads him to use tools and machinery. Six simple machines.
9. Wednesday, March 8.
   Machinery limited in its uses. Friction, tension and thrusts.
10. Wednesday, March 15.
    Liquids may be used to increase force or speed of action. Liquid pressure. The hydrostatic paradox.
11. Wednesday, March 22.
    Why some bodies float in water. Densities and specific gravities.
12. Wednesday, March 29.
    How liquids climb in tubes. Surface tensions, films and capillarity.
13. Wednesday, April 5.
    The turbulent ocean in which we live. Atmospheric pressure, barometers, weather maps. Compressibility of gases.
14. Wednesday, April 12.
    How gas properties are studied and measured. Three gas laws. Atmospheric density and buoyancy.

MUSEUM TALKS

Monday evenings at 7 o'clock

This series comprises informal talks, given on Monday evenings, illustrated by specimens in the Museum.

PROFESSOR HOWELL

The Contents of the Rocks

Sept. 12.	The Minerals of the Once Molten Rocks.
Sept. 19.	The Minerals of the Water-laid Strata.
Sept. 26.	The Minerals Filling Cavities in the Earth's Crust.
Oct. 3.	Plant Fossils and how they were Formed.
Oct. 10.	The Fossils of Animals which had External Armor.
Oct. 17.	Fossil Bones and the Story They Tell.

PROFESSOR SCHMUCKER

How Animals Feed

Oct. 24.	Why Animals need Food.
Oct. 31.	Parasites.
Nov. 7.	Seed Eaters.
Nov. 14.	Flesh Eaters.
Nov. 21.	Nibblers.
Nov. 28.	Cud Chewers.

MISS BORDEN

How Animals Outwit Their Foes

Dec. 5.	How the Lowest Animals Defend Themselves.
Dec. 12.	Self-Preservation Among the Jointed-Legs.
Dec. 19.	Weapons and Devices of the Finny Tribe.
Dec. 26.	No Lecture.
Jan. 2.	Body Coverings that Fool the Foe.
Jan. 9.	How Birds Escape Their Enemies.
Jan. 16.	Methods of Defense Among the Higher Animals.

MR. LAWRENCE

Reproductive Problems in the Animal Kingdom

Jan. 23.	Lobsters and Other Crustaceans with Reference to Their Reproductive Habits.
Jan. 30.	The Family Life of Spiders and Their Cousins.
Feb. 6.	Insects, Their Nests and Eggs.
Feb. 13.	No Lecture.
Feb. 20.	Fish and Amphibians in Relation to Their Young.
Feb. 27.	The Care of Reptiles and Birds for Their Offspring.
Mar. 6.	Mother Love among the Mammals.

PROFESSOR KAISER

Great Groups of Plants

Mar. 13.	Banana, Ginger, Canna, Zebra Plant.
Mar. 20.	Sweet Shrub, Custard Apple, Nutmeg, Laurel.
Mar. 27.	Pitcher Plant, Nepenthes, Sundew.
Apr. 3.	Stonecrop, Houseleek, Saxifrage, Currant.
Apr. 10.	Papaw, Begonia, Cactus.
Apr. 17.	Primrose, Leadwort, Sapodilla, Persimmon.

GENERAL SCHEDULE OF REGULAR LECTURES

Subjects of courses in each of the four successive years constituting a full term.

ENGINEERING

1. Materials of Engineering Construction.
2. Civil Engineering Structures.
3. Roads, Railroads and Tunnels.
4. Water Supply, Sewers, Canals, Rivers and Harbors.

PHYSICS

1. Properties of Matter. Mechanics.
2. Heat and Sound.
3. Light.
4. Electricity and Magnetism.

INORGANIC CHEMISTRY

1. General Principles, Notation, Nomenclature.
2. Descriptive Chemistry.
3. Descriptive Chemistry.
4. Descriptive Chemistry.

ORGANIC CHEMISTRY

1. General Principles, Aliphatic Hydrocarbons.
2. Carbohydrates, Fats, Oils and Waxes.
3. Cyclic Hydrocarbons.
4. Compounds of Nitrogen.

ZOOLOGY

1. Invertebrate Animals.
2. Vertebrate Animals.
3. Human Biology.
4. Principles of Animal Life.

BOTANY

1. Morphology.
2. Taxonomy.
3. Taxonomy (continued).
4. Physiology and Ecology.

GEOLOGY AND PALEONTOLOGY

1. Physical Geography.
2. Physical Geology.
3. Paleontology.
4. Historical Geology.

LECTURES UNDER RICHARD B. WESTBROOK FOUNDATION

1912.—Ancient Civilization of Babylonia and Assyria. *Morris Jastrow, Jr., Ph.D.*

1913.—Conservation of Natural Resources. *Gifford Pinchot, Marshall O. Leighton, Overton W. Price, Joseph A. Holmes.*

1914.—The Theory of Evolution. *William Berryman Scott, Ph.D., LL.D.*

1915.—Invisible Light. *Robert Williams Wood, LL.D.*

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1918.—The Chemistry, Nutritive Value and Economy of Foods. *Harvey W. Wiley, A.M., M.D., B.S., Ph.D., LL.D., D.Sc.*

1919.—The Origin and Antiquity of the American Indian. *Aleš Hrdlička, M.D., Sc.D.*

1920.—Chemistry and Civilization. *Allerton S. Cushman, B.S., A.M., Ph.D.*

1921.—Microbiology. *Joseph McFarland, M.D., Sc.D.*

1922.—Evolution of the Human Face. *William K. Gregory, Ph.D.*

1923.—The Philosophy of Sanitation. *George C. Whipple, B.S.*

1924.—The Distribution of American Indian Traits. *Clark Wissler, A.M., Ph.D.*

1925.—Structural Colors. *Wilder D. Bancroft, Ph.D., Sc.D.*

1926.—The Animal Mind; its sources and evolution. *George Howard Parker, Sc.D.*

1927.—An Interpretation of Atlantic Coast Scenery. *Douglas W. Johnson, Ph.D.*

1928.—The Science of Musical Sounds. *Dayton C. Miller, Ph.D.*

1929.—Volcanoes and Vulcanism. *William B. Scott, Ph.D., LL.D.*

1930.—Present Problems of Evolution. *Edwin Grant Conklin, Ph.D., ScD., LL.D.*

1931.—The Problems of the Origin and Antiquity of the American Aborigines in the Light of Recent Explorations. *Aleš Hrdlička, M.D., Sc.D.*

1932.—Common Sense, Science and Philosophy. *John Dewey, Ph.D., LL.D.*

1933.—Social Relations in Monkey, Ape and Man. *Robert M. Yerkes, A.M., Ph.D., Sc.D.*

1934.—Chemistry and Industrial Progress as exemplified in the Study of Hydrogen and Oxygen. *Hugh S. Taylor, D.Sc., F.R.S.*

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BULLETIN
of the
WAGNER FREE INSTITUTE OF SCIENCE
PUBLISHED BY THE INSTITUTE
SYDNEY L. WRIGHT, *Editor*

Vol. 13 Quarterly $1.00 per year
No. 4 NOVEMBER, 1938 Single numbers, 25 cents

THE SPONGE, "*Zittelella varians*," FROM THE ORDOVICIAN OF VERMONT

By BENJAMIN F. HOWELL, A.M., PH.D.

Although fossil sponges have been found in rocks of all ages from the Cambrian to the Quaternary, they are comparatively rare in Cambrian and Ordovician strata. One Ordovician species, however, whose name is usually given as "*Zittelella varians* (Billings),"[*] is widely distributed in the Chazyan of eastern North America. It has been recorded from Chazyan rocks of the Mingan Islands (Quebec) and of New York, Vermont,[†] Pennsylvania, and Tennessee.[‡]

Unfortunately the author of this widely distributed species did not figure it when he described it, and no illustration of it appears to have been published until W. H. Twenhofel figured specimens from the Mingan formation of the Mingan Islands early in 1938.[§]

Billings placed this species in his genus *Eospongia*, of which *E. roemeri* is the genotype; but it has since been assigned to *Zittelella*, a genus later proposed by E. O. Ulrich and Oliver Everett,[||] with *Zittelella typicalis*, from the Black River rocks of Illinois as the genotype. Ulrich[¶] still considers that *varians* belongs in *Zittelella;* but Twenhofel believes that genus to be identical with Billings' *Eospongia*, and calls the species "*Eospongia varians.*"

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[*] E. Billings: On some new species of fossils from the Calciferous, Chazy, Black River, and Trenton formations. In Report on the Geology of Vermont, vol. 2 (1861), p. 956. Also in Paleozoic Fossils, vol. 1 (1865), pp. 19–20 (advanced sheets published in 1861).

[†] H. M. Seely: Some sponges of the Chazyan formation. Report of the State Geologist on the Mineral Industries and Geology of Certain Areas of Vermont for 1901–1902 (1902), pp. 151–161, pl. 56–59.

[‡] R. S. Bassler: Bibliographic Index of American Ordovician and Silurian fossils. United States National Museum Bulletin 92 (1915), pp. 1338.

[§] W. H. Twenhofel: Geology and Paleontology of the Mingan Islands. Geological Society of America, Special Paper 11, pl. 5, fig. 2, pl. 6, figs. 3 and 10.

[||] E. O. Ulrich and Oliver Everett: Description of Lower Silurian sponges. Geological Survey of Illinois, vol. 8 (1890), pp. 267–268.

[¶] Personal communication.

In order that a figure of the holotype of this common sponge and further information as to its occurrence in Vermont may be available to future students of Chazyan faunas, illustrations of the holotype and of a specimen from the Chazy Limestone of Isle La Motte, northwestern Vermont, which is preserved in the Paleontological Museum of Princeton University, are presented here. The holotype, which is from the Mingan Islands, and presumably came from beds of the Mingan formation, is figured through the courtesy of Dr. E. M. Kindle. It is no. 999 f and h in the Canadian National Museum.

That individual specimens of *Zittelella varians* differed much in the form of their bodies is demonstrated by Twenhofel's figures and our illustrations of the holotype (figs. 3 and 4) and the Isle La Motte example (figs. 1 and 2). Nor do these examples reach the limits of variability of the species. Indeed, were only a few examples available, and were those as unlike each other as are some of those of which figures have been published, one would be justified in suspecting that more than a single species was represented. An examination of the many specimens of *Zittelella varians* in the collections of the United States National Museum indicates, however, that all are referable to a single variable species. Such variability in body form is not uncommon in some species of sponges.

A description of the Isle La Motte specimen preserved at Princeton and a comparison of it with the holotype of *Z. varians* and with other species of *Zittelella* will serve to supplement the brief description of *varians* published by Billings and the description and figures presented by Twenhofel, and will give the reader additional information about the characters which distinguish the species and separate it from other related forms. It is hoped that some investigator who can compare specimens of *Eospongia roemeri* and all the species which have been referred to *Zittelella* will be able to present conclusive evidence which will demonstrate whether all of them belong in a single genus, as Twenhofel claims, or whether *Zittelella* is valid, as is believed by Ulrich. Because the evidence of the spicules and canals appears to be at present inconclusive, and because the species, *varians* and *typicalis* (the genotype of *Zittelella*), are similar in their turbinate form, while *Eospongia roemeri* differs from them in being pyriform in shape, the author has left *varians* tentatively in *Zittelella* in the present paper.

DESCRIPTION OF SPECIMEN OF *Zittelella varians* FROM CHAZY LIMESTONE OF ISLE LA MOTTE, VERMONT

The body appears to have been turbinate in form. It is 1½ inches wide and somewhat more than 1 inch in height. (Its base is so poorly preserved that its height can not be exactly determined.) The osculum is ½ inch wide. Nothing can be learned about the form of the paragastric cavity. The upper surface of the body is horizontal, and is crossed by many furrows, which radiate from the osculum. The sides of the body are also covered with irregular vertical furrows. Very little can be ascertained from this specimen concerning the shape of its spicules, but they appear to have the general form which is said by Ulrich and Everett, who proposed and defined the genus *Zittelella*, to be characteristic of that genus.

The Isle La Motte specimen differs from the holotype of *Z. varians* in being smaller and in having the upper surface flat, instead of rounded, and it is smaller and narrower than the specimens figured by Twenhofel. It differs from the Illinois Black River species, *Z. typicalis*,* the genotype of *Zittelella*, in shape (for *typicalis* is mushroom-like in form) and in its smaller size and larger osculum; and from *Z. osculata*, another Black River species from Illinois,† in its lesser height and larger osculum.

The specimen is no. 42746 in the paleontological collection of Princeton University. It was collected from a limestone bed of the Lower Ordovician Chazy Formation on the eastern side of the road running to Lucile Manor, on Isle La Motte, Vermont.

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* Ulrich and Everett, *op. cit.*, p. 271, pl. 5, f. 3, 5.

† Ulrich and Everett, *op. cit.*, p. 271, pl. 5, f. 6.

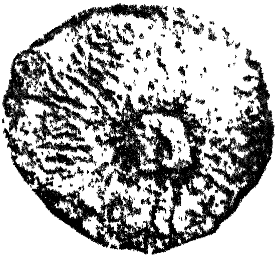
EXPLANATION OF PLATE

Fig. 1: Top view of specimen of ***Zittelella variens*** (Billings) from the Chazy Formation of Isle La Motte, Vermont. Natural size.

Fig. 2: Side view of the same specimen. Natural size.

Fig. 3: Polished face of vertical section of the holotype of ***Zittelella varians*** (Billings) from the Chazyan of the Mingan Islands, Quebec. 1½ times natural size.

Fig. 4: Top view of the holotype. 1½ times natural size.



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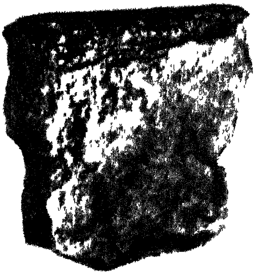

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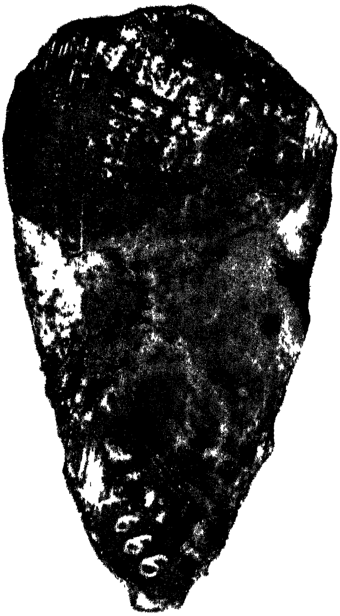

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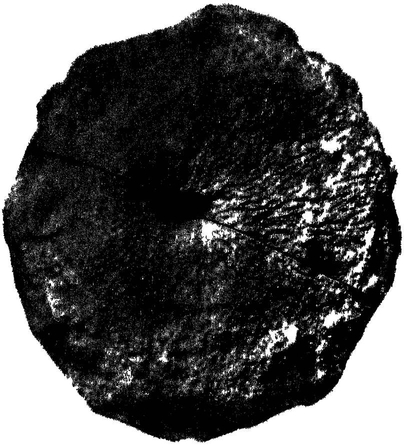

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